VERTEBRAL PATHOLOGIES IN SKELETONS OF ALASKAN ESKIMOS FROM GOLOVIN BAY AND NUNIVAK ISLAND

A

DISSERTATION

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

By

Scott S. Legge, B.A., M.A.

Fairbanks, Alaska

December 2002

UMI Number: 3071431

UMI Microform 3071431

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

VERTEBRAL PATHOLOGIES IN SKELETONS OF ALASKAN ESKIMOS FROM GOLOVIN BAY AND NUNIVAK ISLAND

By

Scott Stephen Legge

RECOMMENDED:

Advisory Committee Chair

Chair, Department of Anthropology

APPROVED:

Dean, College of Liberal Arts

Dean of the Graduate School

12-12-02

Date

Abstract

The primary objectives of this dissertation are to analyze vertebral pathologies by comparing two Native Alaskan skeletal collections, and assessing these results in terms of the patterning of genetically controlled versus activity related lesions. Skeletal collections housed at the Smithsonian Institution were requested for repatriation by the residents of Golovin Bay and Nunivak Island in 1993 and 1994, respectively. Prior to reburial, the remains were analyzed utilizing the Smithsonian Protocol of Skeletal Analysis (Ureid and Byrd, 1995) at the University of Alaska Fairbanks. Vertebral anomalies and pathologies observed in this study include spondylolysis, spina bifida occulta, Schmorl's nodes, osteoarthritis, transitional lumbosacral vertebrae, vertebral fusion, and fractures.

Activity related pathologies, such as Schmorl's nodes and osteoarthritis, are significantly different when the two sampless are compared. No differences are observed for spina bifida occulta or transitional lumbosacral vertebrae, conditions with a genetic origin. Spondylolysis is believed to be a genetically transmitted trait (Fredrickson et al., 1984; Hensinger, 1989; Kettelkamp and Wright, 1971; Merbs, 1983; Ortner and Putschar, 1985; Stewart, 1956; Wiltse et al., 1975), but is not manifested without a triggering mechanism such as stress or fatigue. Frequencies of spondylolysis are found to be significantly higher among the individuals from Golovin Bay when compared globally to other samples, resembling frequencies observed by other researchers for skeletal collections from the Canadian Arctic and Greenland.

Vertebral health among the Golovin Bay skeletal collection is characterized as poor. The high prevalence of spondylolysis, coupled with osteoarthritis and intervertebral disc herniations, speaks of clinically significant back problems in both males and females, although not necessarily from the same causes. Individuals from Nunivak Island show slightly better vertebral health than that of Golovin. They are characterized by nearly no spondylolysis and generally less osteoarthritis. Based upon these observations it would appear that the subsistence related activities of the people of Golovin Bay took a much greater toll on the back than did the activities of those living on Nunivak Island.

TABLE OF CONTENTS

TABLE OF CONTENTS V

LIST OF FIGURES VIII

LIST OF TABLES X

ACKNOWLEDGMENTS XII

INTRODUCTION 1

Research objectives 1

Organization, goals, and assumptions 2

PAST PALEOPATHOLOGY STUDIES IN THE ARCTIC 7

Spinal Pathologies in the Early Literature 9

HISTORY OF THE GOLOVIN BAY AND NUNIVAK ISLAND PEOPLE 12

Background: Nunivak Island 14

Archaeology 16

Population History 19

Subsistence 20

Background: Golovin Bay 22

Archaeology 23

Population History 24

Subsistence 25

REVIEW OF VERTEBRAL PATHOLOGIES AND ANOMALIES 27

Spondylolysis 28

Spina bifida occulta 35

Schmorl's nodes 36

Osteoarthritis/Degenerative Joint Disease 37

Sacralization of L5/L6 and Lumbarization of the sacrum....39
Presacral Vertebral Fusion....40
Fractures and wedging....43

METHODS AND MATERIALS....45
Spondylolysis....47
Recording methods....47
Golovin Bay materials....47
Nunivak Island materials....48
Spina bifida occulta....49
Recording methods....49
Golovin Bay materials....49
Nunivak Island materials....49
Schmorl's nodes....51
Recording methods....51
Golovin Bay and Nunivak Island materials....51
Osteoarthritis/Degenerative Joint Disease....51
Recording methods....51
Golovin Bay and Nunivak Island materials....53
Transitional lumbosacral vertebrae....53
Presacral fused vertebrae....54
Fractures and wedging....54
Statistical analysis....55

RESULTS....57
Spondylolysis: Golovin Bay....57
Spondylolysis: Nunivak Island....58
Spina bifida occulta: Golovin Bay....60
Spina bifida occulta: Nunivak Island....62
Schmorl's nodes: Golovin Bay....64

Schmorl's nodes: Nunivak Island 66
Osteoarthritis/Degenerative Joint Disease: Golovin Bay 70
Osteoarthritis/Degenerative Joint Disease: Nunivak Island 71
Transitional lumbosacral vertebrae: Golovin Bay 75
Transitional lumbosacral vertebrae: Nunivak Island 76
Presacral fused vertebrae: Golovin Bay 79
Presacral fused vertebrae: Nunivak Island 79
Fractures and wedging: Golovin Bay 80
Fractures and wedging: Nunivak Island 81

DISCUSSION 83
Spondylolysis 84
Spina bifida occulta 91
Schmorl's nodes 93
Osteoarthritis/Degenerative Joint Disease 94
Transitional lumbosacral vertebrae 95
Fused vertebrae 97
Fractures and wedging 105

SUMMARY AND CONCLUSIONS 113

LITERATURE CITED 120

APPENDICES 136
A Scoring Codes from Ureid and Byrd (1995) 136
B Inventory of Individuals from Golovin Bay 139
C Inventory of Individuals from Nunivak Island 181
D Sample Statistics 213

LIST OF FIGURES

Figure 1. Locations of Golovin Bay and Nunivak Island...12
Figure 2. Map of Golovin Bay area..13
Figure 3. Map of Nunivak Island...13
Figure 4. Bering Straits Eskimo with a seal harvest...14
Figure 5. The three most common locations of spondylolysis.......................................30
Figure 6. Spondylolysis of the fourth and fifth lumbar vertebrae of a middle adult female (AMNH #352408) from Golovin Bay, Alaska..58
Figure 7. Complete *spina bifida occulta* in a middle adult male (AMNH #352394) from Golovin Bay, Alaska..61
Figure 8. Partially open sacral canal in a young adult male (AMNH# 339107) from Nunivak Island, Alaska..63
Figure 9. Schmorl's nodes on the second and third lumbar vertebrae of a middle adult male (AMNH #339256) from Nunivak Island, Alaska..67
Figure 10. Extreme osteophyte development on L1-L5 of a middle adult male (AMNH #352394) from Golovin Bay, Alaska..72
Figure 11. Transitional lumbosacral vertebra attached to the sacrum of a middle adult female (AMNH #346001) from Golovin Bay, Alaska..77
Figure 12. Transitional lumbosacral vertebra attached to the sacrum exhibiting incomplete closure of the neural arch...78
Figure 13. Bering Strait Eskimos using harnesses to pull a sled loaded with building supplies..88
Figure 14. Congenitally fused (segmentation failure) second and third cervical vertebrae from a middle adult female (AMNH #352379A) from Golovin Bay, Alaska................98
Figure 15. Congenitally fused (segmentation failure) third and fourth cervical vertebrae of a late adolescent male (AMNH #346033) from Golovin Bay, Alaska.....................99
Figure 16. Fused eleventh and twelfth thoracic vertebrae with severe osteophytic remodeling from an old adult female (AMNH #346028) from Golovin Bay, Alaska..101

Figure 17. Ribs fused to the thoracic vertebrae in a young adult male (AMNH #346117A) with rheumatoid arthritis from Golovin Bay, Alaska. 102

Figure 18. Congenitally fused (segmentation failure) second and third cervical vertebrae of a young adult female (AMNH #339228) from Nunivak Island, Alaska. 103

Figure 19. Congenitally fused (segmentation failure) second and third cervical vertebrae of an adolescent child (AMNH #339235) from Nunivak Island, Alaska. 104

Figure 20. Compression fracture of a sixth thoracic vertebra from a middle adult male (AMNH #346012) from Golovin Bay, Alaska. 107

Figure 21. Superior (top) and inferior (bottom) views of sagitally cleft vertebral body of T7 from an unknown sex adolescent (AMNH #346109) from Golovin Bay, Alaska. . 108

Figure 22. Inferior view of cleft centrums of the second and third cervical vertebrae from a late adolescent of indeterminate sex (AMNH #339163) from Nunivak Island, Alaska. 110

Figure 23. Superior view of cleft centrums of the second and third cervical vertebrae from a late adolescent of indeterminate sex (AMNH #339163) from Nunivak Island, Alaska. 111

LIST OF TABLES

Table 1. Research chronology on Nunivak Island. 17
Table 2. Current subsistence resources utilized at Mekoryuk and Golovin 22
Table 3. Age category descriptions 46
Table 4. Lumbar vertebrae counts for Golovin and Nunivak. 48
Table 5. Sacra counts for Golovin and Nunivak. 50
Table 6. Vertebra counts by segment for Golovin Bay and Nunivak Island. 52
Table 7. Golovin Bay spondylolysis counts and frequencies for individuals with complete lumbar segments L1-L5. 59
Table 8. Individual lumbar vertebra spondylolysis counts and frequencies for Golovin Bay 59
Table 9. Nunivak Island counts and frequencies of *spina bifida occulta* using all observable sacra. 64
Table 10. Presence of Schmorl's nodes for Golovin Bay and Nunivak Island among individuals with at least one observable vertebra. 65
Table 11. Counts and frequencies of Schmorl's nodes by vertebral segment for Golovin Bay 65
Table 12. Frequencies of Schmorl's nodes by age category for Golovin Bay. 66
Table 13. Counts and frequencies of Schmorl's nodes by vertebral segment for Nunivak Island. 68
Table 14. Frequencies of individuals with Schmorl's nodes by age category for Nunivak Island. 68
Table 15. Counts and frequencies of vertebrae with Schmorl's nodes by vertebral segment for Golovin Bay and Nunivak Island males. 69
Table 16. Counts and frequencies of vertebrae with Schmorl's nodes by vertebral segment for Golovin Bay and Nunivak Island females. 70
Table 17. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Golovin Bay. 71

Table 18. Frequencies of osteoarthritis (OA)/DJD by age category for Golovin Bay....71
Table 19. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Nunivak. 73
Table 20. Frequencies of osteoarthritis (OA)/DJD by age category for Nunivak. 74
Table 21. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Golovin Bay and Nunivak Island males. 74
Table 22. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Golovin Bay and Nunivak Island females. 75
Table 23. Transitional lumbosacral counts by age and sex for Golovin Bay. 76
Table 24. Presence of transitional lumbosacral vertebrae for Golovin Bay and Nunivak Island among individuals a complete lumbar segment and sacrum. 76
Table 25. Summary of fused vertebrae at Golovin. 79
Table 26. Summary of vertebral wedging at Golovin Bay. 81
Table 27. Summary of vertebral wedging at Nunivak Island. 82
Table 28. Frequencies of spondylolysis for Golovin Bay, Nunivak Island, and 13 other populations. 85
Table B1. Inventory of cervical vertebrae and spinal pathologies in Golovin Bay collection 175
Table B2. Inventory of thoracic vertebrae and spinal pathologies in Golovin Bay collection 177
Table B3. Inventory of Lumbar vertebrae and spinal pathologies in Golovin Bay collection 179
Table C1. Inventory of cervical vertebrae and spinal pathologies in Nunivak Island collection 207
Table C2. Inventory of cervical vertebrae and spinal pathologies in Nunivak Island collection 209
Table C3. Inventory of cervical vertebrae and spinal pathologies in Nunivak Island collection 211

ACKNOWLEDGMENTS

I would like to thank the people of Golovin Bay and Nunivak Island, Alaska for graciously allowing this analysis to be conducted at the University of Alaska. My dissertation committee members, Dr. Joel Irish (Chair), Dr. S. Craig Gerlach, Dr. G. Richard Scott, and Dr. Ron Barry, have all been instrumental in the completion of this work. I would especially like to acknowledge Dr. G. Richard Scott, who was responsible for interacting with the residents of Golovin Bay and Nunivak Island on behalf of the University of Alaska, and whose drive and motivation kept the analysis on track and working smoothly. Dr. Scott also provided the opportunity to work with these two skeletal collections, and introduced me to Alaska and its incredible people.

Special thanks should also be made to Dr. Joel Irish, without whom this project may never have been finished. Dr. Irish's encouragement and help in obtaining funding were a key to its completion. The laboratory analysis crew consisted of C. Ryan Colby, Robert Lane, Susan Steen, and Steven R. Street. All photographs of remains from both Golovin Bay and Nunivak Island are courtesy of Dr. G. Richard Scott. I must also thank Matthew Ganley for discussions about the current residents of the Golovin Bay region and Peter Bowers for providing me with the opportunity to travel to numerous villages around the state of Alaska. The others who have touched this project in some way are too numerous to mention, but their input and support has been invaluable. Finally, I must thank my wife, Dr. Michelle Epp; this work would never have even taken place without her support, encouragement, and willingness to endure seven years of graduate school induced poverty.

The Smithsonian Institution Repatriation Office provided partial funding for this project. Further support was provided by the Department of Anthropology, Alaska Quaternary Center, and the Graduate School of the University of Alaska Fairbanks.

All mistakes and omissions, which I hope are few in number, are the sole responsibility of the author.

INTRODUCTION

Research objectives

The present dissertation contains sections on the general culture history background of the Nunivak Island and Golovin Bay regions, background discussion of vertebral column pathologies observed in Native Alaskan skeletal populations, characterization of these vertebral pathologies as observed in the skeletal collections from the aforementioned areas, and a discussion of the implications of these observations with regard to subsistence related activities in the areas. Comparisons are made between the two samples based on the frequencies of these pathologies in the collections. It is hypothesized that conditions with a known genetic etiology will be similar between the two groups and that those more closely tied with subsistence related activities will show marked differences. It is also expected that males and females would differentially exhibit pathologies tied to subsistence, as previous researchers have noted among other Arctic populations. Another question that may be addressed in research of this nature concerns the usefulness of data collected prior to repatriation as a tool for anthropologists to answer questions about the activities of past populations. This is important because the data collected prior to repatriation are essentially the last word on the subject before the remains are reburied.

In this study I am trying to not only present descriptive information, but to provide the basis for a better understanding of the earlier people in both areas of study. With the enactment of the Native American Graves Protection and Repatriation Act of

1990 (NAGPRA, 1990), skeletal collections housed in museums around the United States became eligible for return and reburial at the request of Native communities. The current residents of Mekoryuk initiated the repatriation process for the Nunivak Island collection in 1994, and the materials were returned to the village in the fall of 1996. Remains from Golovin Bay were initially requested for repatriation in 1993, and were subsequently returned in 1996. When the skeletal materials discussed below were reburied, there was apparently a sense of closure for many families in both communities, while at the same time, a potentially rich window into the past for both populations was lost.

Organization, goals, and assumptions

Although the provenience information for most of the skeletal materials utilized in the current study are not more detailed than general geographic location, a working understanding of the nature of archaeological investigations in both the Norton Sound and Nunivak Island areas is important for assessing the cultural backgrounds of the people discussed in this study. I will include a brief overview of the archaeological investigations that have taken place in each of the regions, as well as general time periods associated with past cultural stages defined by previous archaeologists.

A number of vertebral pathologies and anomalies will be examined in both of the aforementioned populations. Anomalies, usually congenital in origin, are cases in which the condition of a vertebra differs from the norm. *Spina bifida occulta* and sacralization and lumbarization are included in the category of anomalies. Pathologies are those cases in which a vertebra has been affected by disease or trauma. Schmorl's nodes, osteoarthritis, and fractures and wedging are examples of pathologies. Some conditions like spondylolysis and vertebral fusion may be classified as an anomaly or a pathology depending on the individual case. All of these conditions will be characterized for both of the study samples and attempts will be made to compare the findings with other populations from around the world. The particular pathologies and anomalies listed above have been chosen for this study because of the combination of genetically related and activity related lesions, and the fact that these are the main vertebral traits recorded in the Smithsonian Protocol for Skeletal Analysis (Ureid and Byrd, 1995). Wherever possible, data from the Golovin Bay and Nunivak Island skeletal samples are compared to published data sets from other global skeletal collections.

The Smithsonian Protocol for Skeletal Analysis (Ureid and Byrd, 1995) methods used for analyzing and recording the data in this study (see Appendix A) are listed for each pathology and anomaly in the section on methodology. The data from Golovin Bay were recorded during the summer of 1995 by a group of researchers and students at the University of Alaska Fairbanks. I did not directly participate in data collection on this first skeletal sample. The Nunivak Island skeletal collection came to the University of Alaska Fairbanks during the summer of 1996, and I was able to fill in some of the gaps in the collection protocol with regard to vertebral pathologies, having had a year to look at the data from the previous summer. I was then able to utilize both data sets in order to attempt to answer the questions posed above.

There are a series of assumptions that have been made with regard to the data sets utilized for this research. First, and arguably the most problematic, is the idea that both samples are random and representative of the populations from which they are derived. Skeletal biologists must always struggle with the problem that any skeletal collection may not be representative of the greater population as a whole; however analysis of the data may still be conducted while always keeping this caveat in mind. Most of the remains analyzed here were collected during the late 19th and early 20th centuries (Collins, 1927; Hrdlička, 1930; Speaker et al., 1996). The collection methods at that time were not as systematic as the methods employed by more recent archaeologists. However, it is assumed that since most of the collections were conducted by individuals from the same institution, if not the same individuals themselves, many of the collection biases would be the same for each collection. One bias that is easily seen when looking at the overall sample of materials from both Golovin and Nunivak is the number of crania in the collections compared to other bones. Crania dominate each of these samples, whereas there are few complete vertebral columns in either collection.

There is also the problem of skeletal collections representing the people who have died, rather than those that lived. This may seem to be obvious, but we must always keep in mind that individuals collected from cemeteries represent people who may have died from complications stemming from many of the pathologies observed in their remains, thus skewing the data toward higher frequencies of those particular pathologies. Once again, it must be assumed that individuals recovered from these locations died of numerous causes, including disease trauma and old age.

Nevertheless, I have taken the data from each of the skeletal samples and attempted to separate it for each of the pathologies and anomalies by age, sex, and vertebral segment wherever possible and/or appropriate. A comparison of the frequencies of each of the conditions listed above with regard to age, sex, and location along the vertebral column may help in our understanding of differences between activity related lesions and genetically influenced pathologies both within and between the earlier peoples of Golovin Bay and Nunivak Island, Alaska.

In the following sections I review past research by looking at paleopathologies in skeletal collections from the Arctic. In particular, I address those studies that have focused on vertebral pathologies. As background, I provide a brief history of the peoples of both Golovin Bay and Nunivak Island as it relates to archaeology, population history, and subsistence patterns in each area. Prior to discussing the methods and specific samples utilized, I review the definitions and etiologies of the vertebral pathologies examined. I then present the results for each specific pathology or anomaly within each of the separate skeletal samples. Data are taken from the skeletal samples and separated for each of the pathologies and anomalies by age, sex, and vertebral segment wherever possible and/or appropriate. In the discussion section, comparisons are made between the frequencies of each of the conditions listed above with regard to age, sex, and location along the vertebral column. Within this context, I also compare the data from this study to published data from other populations. Finally, I discuss the implications of the similarities and differences between the collections with regard to activities of the people from each of the locations. I hope that these comparisons will help in our understanding of differences between activity related lesions and genetically influenced pathologies both within and between the earlier peoples of Golovin Bay and Nunivak Island, Alaska.

PAST PALEOPATHOLOGY STUDIES IN THE ARCTIC

Following Moodie's (1923) publication on paleopathologies, biological anthropologists became more interested in the examination of anomalies and pathologies observed in Eskimo skeletons. Research in the early 1900s was oriented toward the effects of harsh arctic lifestyles on the skeleton (Birket-Smith, 1924; Heinbecker, 1928; Krogh and Krogh, 1913; Stefansson, 1922). However, because the diagnosis of disease from dried bones is difficult, it must always be approached with caution. Nevertheless, some pathological conditions may clearly be described, even without a good knowledge of the causes leading to them. For example, broken bones, healed or otherwise, are good indications of overall stresses endured by individuals during their lives. Diseases that directly affect bones, such as cancer, tuberculosis, and various infections, are more difficult to differentiate because many of these pathologies cause similar changes to the bone (Ortner, 1992; Ortner and Putschar, 1985; Wood et al., 1992). Moreover, most diseases must reach very late stages of development to cause observable bone remodeling. There is also debate about the overall effectiveness of using skeletal pathologies, and even basic skeletal analysis, in the study of paleodemography and paleoepidemiology (Goodman, 1993; Wood et al., 1992). For activity related pathologies, bones represent the most direct evidence we have for the stresses endured during an individual's life. Therefore, it is appropriate to utilize skeletal material to estimate how previous populations lived.

Few large-scale paleopathological analyses have been carried out on Alaskan or Canadian Eskimo remains. The few notable exceptions include: Way's (1978) study of a collection of late prehistoric/early historic skeletal material from Labrador, Lobdell's (1980) description of a small collection of skeletal material from two sites in the Kachemak Bay, Alaska area, Merbs' (1983) examination of the Sadlermiut of Southampton Island in northern Hudson's Bay in the Canadian Arctic, Salter's (1984) analysis of two Thule cemetery collections from Baffin Island, and a comparison of skeletal collections from northern coastal Alaska and the Aleutians by Keenleyside (1998).

Several authors (Dubos, 1965; MacMahon and Pugh, 1970) have noted a general link between environment and diseases in humans. Stewart (1973) believed the earliest populations coming to North America from Asia via the Bering Land Bridge passed through what he called a "germ filter," caused by the harsh climate of the north. He claimed that diseases of the Old World were, in essence, left behind, and consequently so were the immunities, explaining why the disease epidemics caused by much later European contacts were so overwhelmingly deadly (Stewart, 1973).

Some later researchers do not share Stewart's viewpoint that Old World diseases were left behind. For example, Fortuine (1989) believes that while the Arctic provides unique environmental challenges for its inhabitants, some of the earliest interactions among Europeans and Alaskan Natives show that environmental challenges were not the only health risks for these early populations. He describes what he believed to be unsanitary conditions in many villages and personal hygiene that did not meet European standards of the time. According to Fortuine, Eskimos and Aleuts would have been exposed to parasitic infections from non-human animal waste, eating raw or undercooked food, and contaminated water (Fortuine, 1989). They would also have been susceptible to many diseases associated with poor sanitation in villages, lack of proper ventilation in their houses, and trauma from methods of transportation such as dog sled (Fortuine, 1989). Despite Fortuine's seemingly overwhelming list of parasites, diseases, and situations of potential trauma, he seems to have overlooked the fact that Eskimo populations across Siberia, Alaska, Canada, and Greenland have survived for thousands of years. In fact, Vilhjalmur Stefansson (1969) paints a much different picture of life in the Arctic than does Fortuine. He sees the possibilities for resource exploitation in nearly every conceivable location of the Arctic based upon his own explorations and experiences (Stefansson, 1969). He believes that life in the Arctic is not nearly as harsh as is commonly thought if one simply knows where to look for food. Nevertheless, there are several pathological conditions that do occur frequently among Arctic skeletal collections, including the main focus of this dissertation, spinal problems and degenerative joint disease.

Spinal Pathologies in the Early Literature

Stewart reports that, beginning in 1926, a series of large Alaskan Eskimo skeletal collections came to the U. S. National Museum (Stewart, 1931). Stewart and others, who had been working with the collections at the time, noted a high incidence of separate neural arches of the lumbar vertebrae, a condition known as spondylolysis

(Stewart, 1931). Earlier investigated instances of this anomaly were reportedly related to a different condition, spondylolisthesis, which involved ventral shifting of the vertebral body. It was believed that spondylelisthesis was directly related to spondylolysis. When the neural arch separates from the vertebral body, the latter is predisposed to ventral shifting, while the inferior articular processes remain in place. When spondylolisthesis occurs in women it can obstruct the birth canal, causing problems during the course of pregnancy. As a result, this condition was originally most often observed and reported in literature relating to obstetrics and gynecology (Stewart, 1931). However, spondylolisthesis is known to occur in both men and women and, in some instances, without the co-occurrence of spondylolysis (Friberg, 1938; Meyerding, 1931).

Stewart (1931, 1932, 1953, and 1956) spent a great deal of time and effort reporting on the various spinal pathologies observed in the Eskimo skeletal collections housed at the National Museum. He found that Northern Alaskan Eskimos had a high frequency of spondylolysis in both men and women. Similar high frequencies of spondylolysis have also been observed in other Arctic populations (Gunness-Hey, 1981; Lester and Shapiro, 1968; Merbs, 1995; Simper, 1986). The etiology of this condition has been a source of great debate since Stewart first described it. Recent research suggests there may be a specific relationship between subsistence strategies and spinal pathologies such as spondylolysis, osteoarthritis, and Schmorl's nodes (Legge, 2000, 2001).

One particular skeletal collection of Sadlermiut Inuit from Southampton Island, Canada, has an interesting history of analysis. The Sadlermiut were first reported on in 1824 by Captain G.F. Lyon (Merbs and Wilson, 1960). Following this, they had limited interaction with European whalers. The Sadlermiut colony perished at some point during the winter of 1902-03 (Merbs and Wilson, 1960). While the cause of the final demise of the Sadlermiut is unknown, several possibilities have been noted, including typhoid fever, typhus, food poisoning, and scurvy (Merbs and Wilson, 1960).

In the summer of 1959, researchers from the University of Wisconsin and University of Toronto went to Southampton Island with the express purpose of collecting human remains. The skeletal collection recovered still provides researchers with an excellent record of many pathologies associated with everyday life in the Arctic (Merbs, 1974, 1983, 1995; Merbs and Wilson, 1960). Merbs (1983) noted relatively high frequencies of vertebral osteophytosis, compression fractures, and spondylolysis. All of these conditions are related to the fundamental activities required for survival in the Arctic; Merbs states that the differences between the sexes are explained by the sexual segregation of subsistence related tasks. He showed higher frequencies of osteoarthritis, vertebral osteophytosis, spondylolysis, and fractures among the Sadlermiut males, whereas females exhibited higher frequencies of compression fractures (Merbs, 1983).

HISTORY OF THE GOLOVIN BAY AND NUNIVAK ISLAND PEOPLE

The history of European contact and interaction at Nunivak Island and Golovin Bay are important background for our understanding of the people inhabiting these locations (Figures 1-3). Population sizes and settlement patterns have changed greatly over the past few hundred years, but the people seem to have remained much the same. The picture that is drawn of current inhabitants of both the Nunivak and Golovin regions is one of subsistence based people with a rich cultural identity (Figure 4).

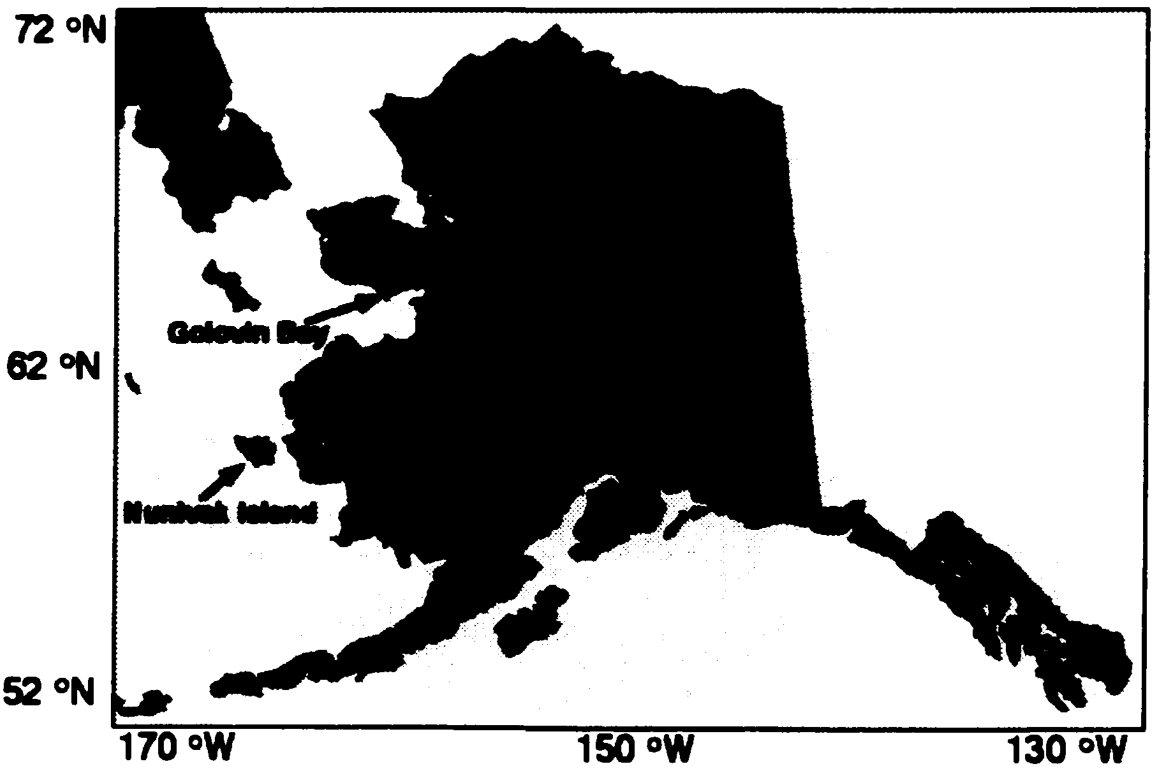

Figure 1. Locations of Golovin Bay and Nunivak Island.

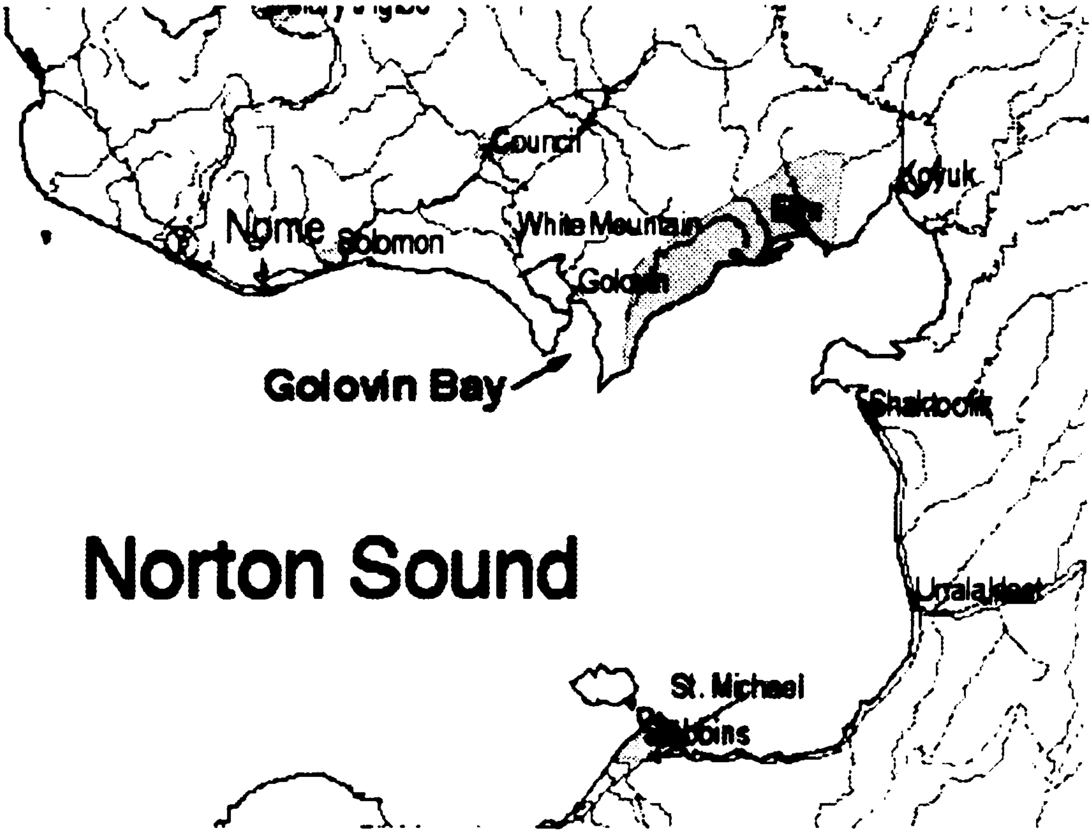

Figure 2. Map of Golovin Bay area.

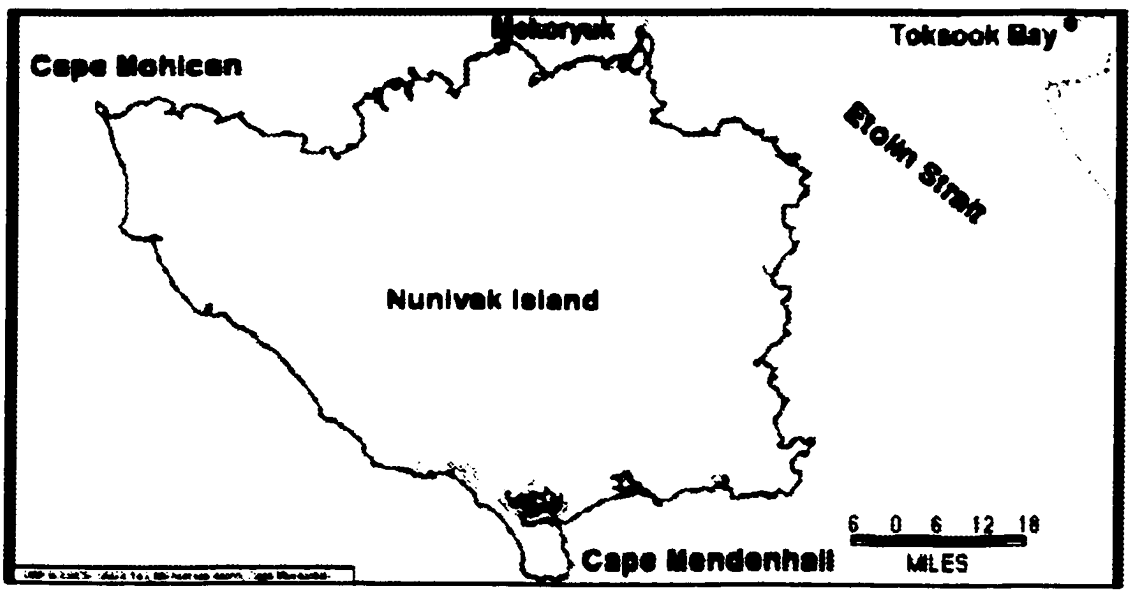

Figure 3. Map of Nunivak Island.

Figure 4. Bering Straits Eskimo with a seal harvest. Photo courtesy of the Historical Photograph Collection, Alaska and Polar Regions Department, University of Alaska Fairbanks.

Background: Nunivak Island

Nunivak Island is located approximately 40 miles off the southwest coast of Alaska in the Bering Sea (60° north and 166° west) (Figure 2). The island is roughly 40 miles wide and 60 miles long, with the majority of the inhabitants currently residing in the village of Mekoryuk on the northern side of the island west of Cape Etolin. Nunivak is volcanic in origin (Pratt, 2001), with the geography of the island consisting of low relief covered by tundra, grasses, and some willow (Lantis, 1984). The highest point on the Island is only 490 meters above sea level (Lantis, 1984). It is also the only major

Bering Sea island presently inhabited by a Central Yupik speaking group (VanStone, 1989).

The circumstances surrounding the "discovery" of Nunivak Island appear to be in dispute. The earliest reported contact with the Native inhabitants apparently comes from Russian Captain Mikhail Nikolaevich Vasil'ev on July 6th 1821 (Ray, 1983). During his visit to the island, interpreters reported to Captain Vasil'ev that the inhabitants had no previous interactions with Europeans. Another account, by Tikhmenev (1978), claims that a different Russian ship, "Golovin," commanded by Captain Khromchenko, discovered Nunivak that same summer. According to Tikhmenev, Kromchenko described Nunivak Island on the 16th and 17th of July, 1821. He acknowledges Vasil'ev's claim that he discovered the island earlier that month, but according to Tikhmenev, Vasil'ev did not report his find until after Kromchenko had already described parts of the island. It is difficult, if not impossible, to determine which individual arrived first, but it seems clear that the Russians made contact with the Native inhabitants of Nunivak Island at some point during the summer of 1821. Interesting to note, that the official "discovery" of Alaska occurred some 80 years previous, by Vitus Bering in 1741 (Ray, 1975), yet Nunivak Island was not documented until the early 1800s.

One explanation for the apparent oversight of an island as large as Nunivak comes from a description of the island and the surrounding seas: "...the sea itself [is] only a shallow encroachment over the continental shelf...a captain...who has to anchor four miles offshore at even the larger villages, exposing his boat to the wind or else the constant risk of going aground, sees no compensations on Nunivak great enough to balance such annoyances" (Lantis, 1946; pg.156). According to Lantis, the effective isolation of the island resulted in many cultural practices being regarded as "backward" when she conducted her ethnographic study in 1939 and 1940. She believed that many of the cultural practices of the Nunivak Island Natives closely resembled those of the island's earlier inhabitants and extrapolated the activities of the population she observed back to an earlier time period (Lantis, 1946). Aleš Hrdlička, of the U.S. National Museum, experienced first hand the problems of landing on Nunivak Island, when he was unable to visit it during his 1926 survey in Alaska due to bad weather and the poorly charted local waters (Hrdlička, 1930). The first permanent trading post on Nunivak was not established until 1920, with the introduction of a private reindeer herd by the Lomen Commercial Company (Griffin, 2001).

Archaeology

Detailed archaeological excavations from Nunivak Island are limited (Table 1). Nevertheless, a chronology for the Island has been established, even if not completely agreed upon. Henry B. Collins conducted the first archaeological testing on Nunivak in the summer of 1927. During his time he collected several pieces of check-stamped pottery, similar to a sample from Norton Sound retrieved by Hrdlička in 1926 (Collins, 1928). The work by Collins was part of a push by Hrdlička to bolster the size of the Eskimo skeletal collections at the U.S. National museum (Hrdlička, 1930).

Table 1. Research chronology on Nunivak Island.

Researcher	Year	Location(s) on Island
Collins	1927	Village of Koot at N.E. End of Island
VanStone	1952	Mekoryuk with a short survey of Cape Mendenhall
Nowak	1967	15 coastal sites from all around the island except S.W. coast.

In 1952, VanStone (1954, 1957) conducted archaeological reconnaissance of the Island over a six-week period. Unfortunately his efforts were hampered by bad weather and transportation problems, leading to the confinement of the majority of his investigations to an area around the town of Mekoryuk, on the northern side of the island. VanStone was able to spend only a short period of time on the south side of the island near Cape Mendenhall (VanStone, 1957), where he observed extensive archaeological sites, but was not able to fully test them. In the north, he collected large amounts of pottery from several sites around Mekoryuk. He stated that artifact preservation was poor, that pottery made up the vast majority of the cultural material collected (VanStone, 1957), and he concluded that the materials collected do not suggest occupation of the island for any substantial period of time. But he does leave open the possibility that the restricted nature of his reconnaissance caused him to overlook sites with greater time depth (VanStone, 1957).

During the summer of 1967, Michael Nowak of Colorado College conducted an archaeological reconnaissance of Nunivak Island, with the hope of establishing an archaeological chronology. The history of occupation of Nunivak Island has been under discussion since the very first investigations were conducted. Both VanStone (1957) and Collins (1928) discussed the presence of check-stamped pottery on Nunivak, although neither of them associated it with an early occupation. Nowak (1970), however, saw the check stamped ware as an early component on Nunivak resembling the Norton period as defined by Giddings (1964) in the Norton Sound Region of western Alaska.

Nowak recovered a large number of check-stamped potsherds in association with small flaked bifaces of chalcedony (Nowak, 1970). All of the bifaces associated with the early component on Nunivak fit into types defined by Giddings (1960, 1964) for the Norton period. These types appear in Norton Sound as early as 2500 B.P. (Giddings,1960; 1964) and in the Bristol Bay area by 2200 B.P. (Cressman and Dumond, 1962). Nowak (1982) further breaks down the Norton phase on Nunivak into two subphases based on stratigraphic and artifact differences. The early phase dates from 2150 to 1700 B.P., and the late phase from 1700 to 1400 B.P. (Nowak, 1982).

The second stage identified by Nowak (1970) has been associated with the Western Thule tradition. He bases this determination on the collection of ceramics, lithics, and bone tools comparable to those observed from numerous sites around Southwestern Alaska. Nowak (1970) also obtained a radiocarbon date of 350 ± 95 B.P. from a charcoal sample out of the late component materials. This date is consistent with other dates for Western Thule-like assemblages from Southwestern Alaska. Nowak believes that the Western Thule period on Nunivak dates from 1100 B.P. into the contact period (Nowak, 1986). Given the occupation dates that Nowak proposes, there is a problem of a nearly 300-year gap between the Norton and Western Thule cultural complexes. Nowak believes this gap can be filled by future archaeological investigations on the island. He simply assumes that the island was continuously inhabited from at least "the beginning of the Christian era" through the time of European contact (Nowak, 1970; pg. 30).

Population History

The village of Mekoryuk is the population center on Nunivak Island, with approximately 210 residents reported in the 2000 U.S. census (U.S. Census Bureau, 2001). Based upon census numbers since European contact, the population of the island has varied greatly in the recent past. Early census figures place the population at over 700 (U.S. Census Office, 1893). Subsequent census numbers show a drop in population to as low as 153 by 1980 (U.S. Bureau of the Census, 1982). Lantis (1984) reports an increase in population between her initial observation of 218 in 1940, to 249 people by 1970. She believes improvements in health care contributed to reduced childhood mortality during this time, although an increase of only 31 people over a 30 year period can hardly be referred to as a trend. Since European contact, epidemics of tuberculosis, whooping cough, and other diseases have decimated the population (Lantis, 1946). According to Lantis (1984), the decline in population from 1970 to present is most likely attributable to changes in subsistence economy and the movement of people off of the island in search of wage labor. However, if population numbers from 1940 to the present are considered, it appears that the population has remained relatively stable over the past 60 years.

The population of Nunivak Island has not always been concentrated at Mekoryuk. Lantis (1946) reports that in the late 19th century there was a large settlement at Cape Mendenhall, on the south side of the island. She suggests that the area may have been abandoned because it was hunted and fished out, and could no longer support the people residing there (Lantis, 1946). VanStone (1957) states that the largest archaeological sites on the island are located in the south, agreeing with Lantis that the Cape Mendenhall area was the population center for the island. Kromchenko also described his meetings with various residents from the southern end of the island for trade during the summer of 1822 (VanStone, 1973). He stopped at several villages on the south and southeast end of the island, all of which are no longer inhabited. More recently, Pratt (2001) estimates a pre-1900 island population at over 1000 people based on his overall assessment of land usage in the interior, as well as along the coast.

Subsistence

Much of the information regarding subsistence for Nunivak comes from the detailed ethnography of Lantis (1946). The main subsistence economy during her stay was seal and sea lion hunting. Exploitation of ocean resources was the primary activity. Sea resources utilized include walrus, beluga, numerous fish species, crab, and mussels; sea birds that use parts of the island as rookeries were also collected. Undoubtedly, earlier populations on the island also had access to caribou. According to Pratt (2001), caribou was a major subsistence resource on Nunivak. He utilized a combination of oral history, archaeological and historical data to determine that caribou was an important resource on Nunivak Island during both the historic and prehistoric periods (Pratt, 2001). However, Lantis (1946) believed that caribou were hunted to extinction on the island at some point between 1880 and 1920. The residents of Nunivak Island utilized the Kayak as their main tool in hunting seal. They apparently did not walk long distances, preferring to use the kayak to travel to other portions of the island. If travel over land was required, they tended to wait until winter when the tundra was frozen and walking was easier (Lantis, 1946). Lantis (1946) also stated that the "Nunivakers" apparent disdain for walking was evident when trading with mainland villages; in this case they preferred to travel along waterways in their umiaks during the summer to reach mainland areas.

Tikhmenev (1978) reported that the hunting of hair seals, walrus, and caribou, and off-shore fishing were the main Nunivak Island subsistence activities. He further describes the Nunivak Natives as leading a sedentary life, only coming to the mainland in summer (Tikhmenev, 1978). While it appears that Tikhmenev received his information about the Nunivak inhabitants from the Russian ship commander Etholen (who visited the island in 1821), his descriptions of their lifestyles are consistent with those by Lantis some 120 years later. Kromchenko compared the lifestyle and customs of the Nunivak Islanders to other Native groups that he had encountered, stating that they were most similar to coastal groups from as far north as Norton Sound (VanStone, 1973).

During his work on the island in 1952, Vanstone (1957) reported that all families participated in a late summer reindeer slaughter from the island herd that was was introduced in the 1920s by the Lomen Commercial Company of Nome (Griffin,

2001) and maintained by the Alaska Native Service. VanStone (1989) still saw sealing as the major subsistence activity, however. He concluded that it was the relative isolation of the island, the lack of commercial resources, the abundance of subsistence resources, and the late European contact that allowed the economy and material culture to remain relatively unchanged from the prehistoric through the historic periods (VanStone, 1989). However, Lantis (1972) noted a great deal of change in the Nunivak Island subsistence economy between her work in the1940s and a subsequent visit in 1960. The island went from being a cultural stage of "about fifty years behind the Nome region" to "one of the most modern and...most prosperous Eskimo communities in Alaska" (Lantis, 1972: p44). Currently the subsistence resources utilized on Nunivak Island include salmon, seal, and reindeer, and at least 55 residents hold commercial fishing licenses for halibut and herring roe (ADCED, 2001) (Table 2).

Table 2. Current subsistence resources utilized at Mekoryuk and Golovin (ADCED, 2001).

Village	Resources
Mekoryuk	Halibut, Herring, Salmon, Seal, Reindeer
Golovin	Salmon, Beluga Whale, Seal, Moose, Reindeer

Background: Golovin Bay

Golovin Bay is located on the south side of the Seward Peninsula, along the northern margin of Norton Sound (64° 30" north and 163° west) (Figure 2). It is oriented roughly north-south and is approximately 25 miles long and between five and 10 miles wide. There is a constriction approximately half way up the bay forming what has been called Golovin Lagoon at the northern end. Rocky Point and Cape Darby form the southwest and southeast boundaries, while the regional boundaries are the Darby Mountains to the East, Bendeleben Mountains to the North, and Kigluaik Mountains to the West. The vegetation surrounding the bay is a combination of moist tundra and brush except for the wet river drainage region on the northern border (Selkregg, 1976).

The Russian Captain Kromchenko first discovered Golovin Bay during the summer of 1821. Immediately after visiting Nunivak Island, Kromchenko made his way north to Norton Sound where he described a bay to the west of Cape Darby; he named the bay Murav'ev (for M.I. Murav'ev, the Russian-American Company manager in Sitka), which was subsequently changed to Golovnin (Golovin), at Murav'ev's request (Tikhmenev, 1978). Kromchenko reported that he was told of an interior waterway to Shishmaref Bay (Inlet), on the northwest coast of the Seward Peninsula. He revised this statement based on information gathered the following year, stating that a portage was required (Kromchenko,1824 cited in Ray, 1975).

Archaeology

Hrdlička was the first to conduct archaeological reconnaissance in the Norton Sound area during the summer of 1926 for the Smithsonian Institution (Hrdlička, 1930). He collected a small amount of human remains and a few artifacts, but did not excavate any sites in the area (Hrdlička, 1930). No archaeological excavations of any size were conducted until 1948 when Giddings excavated a number of sites in the

Norton Sound Region (Giddings, 1949, 1951, 1960). Giddings (1960) constructed a chronology for the Bering Sea region, although several authors (Dumond, 2000; Mason and Gerlach, 1995) have pointed out problems with Giddings' dates for this region. Recently, new dates have been proposed for several "type" sites, including Nukleet based on a reevaluation of stratigraphy, chronology, and direct radiometric dating of so-called "type" artifacts (Murray et al., In Review).

Population History

The general settlement pattern of the Golovin Bay region prior to European contact is believed to be a single large village, with a series of smaller, linguistically related villages within a 30 mile radius (Ray, 1964). The settlement of Golovin itself has also gone by the native name of Chinik (or Chingnak) (Ray, 1964). The location of the village was purportedly a prime spot for hunting beluga, seals, ducks and geese, and fishing (Ray, 1964). The settlement there was small, until commercial mining operations on the Seward Peninsula in 1880 made their headquarters in the village of Golovin (Ray, 1964).

Many different estimates for population size in the region have been made, yet there is no consensus on what the true figures may be; however, it is clear that there were many more inhabitants in the region before European contact. Using historic accounts, Ray (1964) estimated that the 19th century population of the Golovin and Koyuk areas was no greater than 400. Based upon essentially the same sources used by Ray, Koutsky (1981) concludes that the population of the Golovin area was no larger than 200. A measles epidemic in 1900 and an influenza epidemic in 1918 had drastic effects on the population size. Koutsky (1981) reported that survivors of these epidemics moved to the larger communities, such as Golovin. The current population of the village of Golovin is 144 (ADCED, 2001).

The people of the Golovin Bay area are said to belong to the Central Yupik language group, although most of the rest of the Seward Peninsula is populated by Iñupiaq speakers (Ray, 1975). This situation poses a problem for ethnographers and archaeologists working in the region, with regard to place names and oral histories (Koutsky, 1981). Despite problems with grouping the settlements by language, residents of Golovin are generally placed with the Fish River People who occupy much of the Fish River drainage from the Bendeleben and Darby Mountains (Sheppard, 1983).

Subsistence

Both land and sea resources were exploited by the inhabitants of Golovin Bay. The resources available would clearly dictate the settlement pattern during any particular season. Ray (1964) classified the Golovin Bay area as falling into the "Small Sea Mammal Pattern" of subsistence. This pattern included a diet mainly of seal and beluga, but was supplemented by land mammals as well (Ray, 1964). Caribou was the most important of the land mammals, ranging in the area until the mid-nineteenth century (Koutsky, 1981). Other land mammals exploited for both food and clothing included hare, ground squirrel, muskrat, wolverine, wolf, and fox (Koutsky, 1981). In the Golovin Bay area in particular, salmon was a very important resource, with three large runs per year of different species coming through Golovin Lagoon (Ray, 1975).

Several other species of both fresh and saltwater fish were utilized, as well as numerous bird species that passed through the region seasonally (Ray, 1975).

Like at Nunivak, reindeer herding was introduced into the area by the U.S. government. The herding lifestyle and problems with government controls had far-reaching effects on traditional activities of many families in the Golovin region (Ray, 1975). Herding could never really replace the traditional hunting and gathering economy, and eventually declined by the mid-1900s (Koutsky, 1981). Recent years have seen a resurgence of reindeer herding, and it remains a viable means of potential income to supplement annual subsistence activities (ADCED, 2001). Despite all of the changes that have taken place with regard to the introduction of non-Native foods and culture practices, the people of the Golovin region still utilize many of the same subsistence resources, and even settlement areas, as did their ancestors (ADCED, 2001; Koutsky, 1981) (Table 2).

REVIEW OF VERTEBRAL PATHOLOGIES AND ANOMALIES

Given the role of the vertebral column in supporting much of the weight and stress in an individual's daily work routine and the preponderance of back-related injuries observed in modern populations, it is necessary to examine the pathologies and anomalies of the vertebral column in skeletal populations in detail. By conducting this type of investigation we gain a better understanding of the habitual stresses and strains endured by earlier populations, as well as the possible genetic background of these conditions. Insight into the differences in spinal pathologies associated with subsistence based economies from two geographically distinct regions of Alaska may also be gained. The skeletal materials from the Golovin Bay and Nunivak Island collections provide just such an opportunity.

The vertebral column in humans normally consists of 24 presacral vertebrae, five fused sacral vertebrae, and four caudal vertebrae, which are the remains of a vestigial tail (Schultz and Strauss, 1945). The presacral vertebrae are further divided into three categories: (1) the seven cervical vertebrae directly support the weight of the cranium and are involved in the rotation of the head and neck; (2) the 12 thoracic vertebrae are the rib bearing vertebrae of the torso; and (3) the five lumbar vertebrae of the lower back are the largest and strongest vertebrae, bearing the greatest amount of weight. Each individual vertebra is made up of a body or centrum (except for the first cervical vertebra, which has no body), a vertebral arch, a spinous process projecting posteriorly, two transverse processes (each projecting laterally), and four articular processes (two superior and two inferior) that articulate with the vertebrae above and below (Bass, 1995). The function of the vertebral column, as a whole, is to protect the spinal cord, provide central muscle attachment and ligament anchoring sites, and transfer the weight of the torso through the pelvis to the legs (White, 1991).

In some human skeletal analyses the vertebrae have been studied in great detail (Allbrook, 1955; Gunness-Hey, 1981; Gunness-Hey, 1982; Lanier, 1939; Lester and Shapiro, 1968; Merbs, 1983; Merbs, 1995; Merbs and Wilson, 1960; Simper, 1986; Stewart, 1953). In many studies, however, the vertebral column has been completely neglected, for a variety of reasons. First, vertebrae do not preserve well when exposed to different taphonomic processes. Second, even under conditions of good preservation, many earlier physical anthropologists collected only skulls. Finally, no standardized methods have been developed to compare the significance of vertebral variations both within and between groups. Therefore, data on vertebral pathologies which are truly comparative among populations, for example examining the same conditions using similar standards, are difficult to find.

Spondylolysis

As mentioned previously, spondylolysis is defined as a separation of the neural arch from the vertebral body (Cyron et al., 1976; Fredrickson et al., 1984). This can be a partial or complete separation of one or both sides of the neural arch (Merbs, 1995). Lysis can occur at several places on the neural arch as well as at the body of the vertebrae (Willis, 1931). The separations that are most often seen in skeletal populations occur on the: (1) lamina, between the transverse process and spinous process; (2) pedicle, attaching the body of the vertebra to the transverse process; and (3) *pars interarticularis*, where the pedicle meets the lamina (Figure 5). This last site is the location where spondylolysis is most often observed (Cyron et al., 1976; Lester and Shapiro, 1968; Merbs, 1995; Willis, 1931). Spondylolytic separations occur most often on the fifth lumbar vertebra (L5), but also occur with decreasing frequency on other lumbar vertebrae as one moves cranially (Gunness-Hey, 1981; Lester and Shapiro, 1968; Stewart, 1931). Separations have also been observed in fused elements of the sacrum, although this is apparently a rare occurrence (Merbs, 1996). There has been some speculation that the different locations of lysis on the vertebral arch could be due to different stresses (Cyron and Hutton, 1978; Cyron et al., 1976; Krenz and Troup, 1973). Recently, Merbs (2002) examined asymmetrical spondylolysis, describing spondylolysis as a process rather than a pathological condition. Unilateral spondylolysis or spondylolysis at different locations bilaterally are then described as different stages in the process of separation (Merbs, 2002), an intriguing result that presents new questions for the analysis of spondylolysis in skeletal collections.

There are three main competing theories regarding the etiology of spondylolysis. First, spondylolysis is thought by some to be the result of a developmental anomaly caused by a flaw in the ossification process of the vertebral arch (Krogman and Iscan, 1986; Saraste, 1985; Willis, 1929, 1931). Second, it is postulated to be a stress fracture resulting from heavy strains on the lower lumbar vertebrae (Cyron and Hutton,

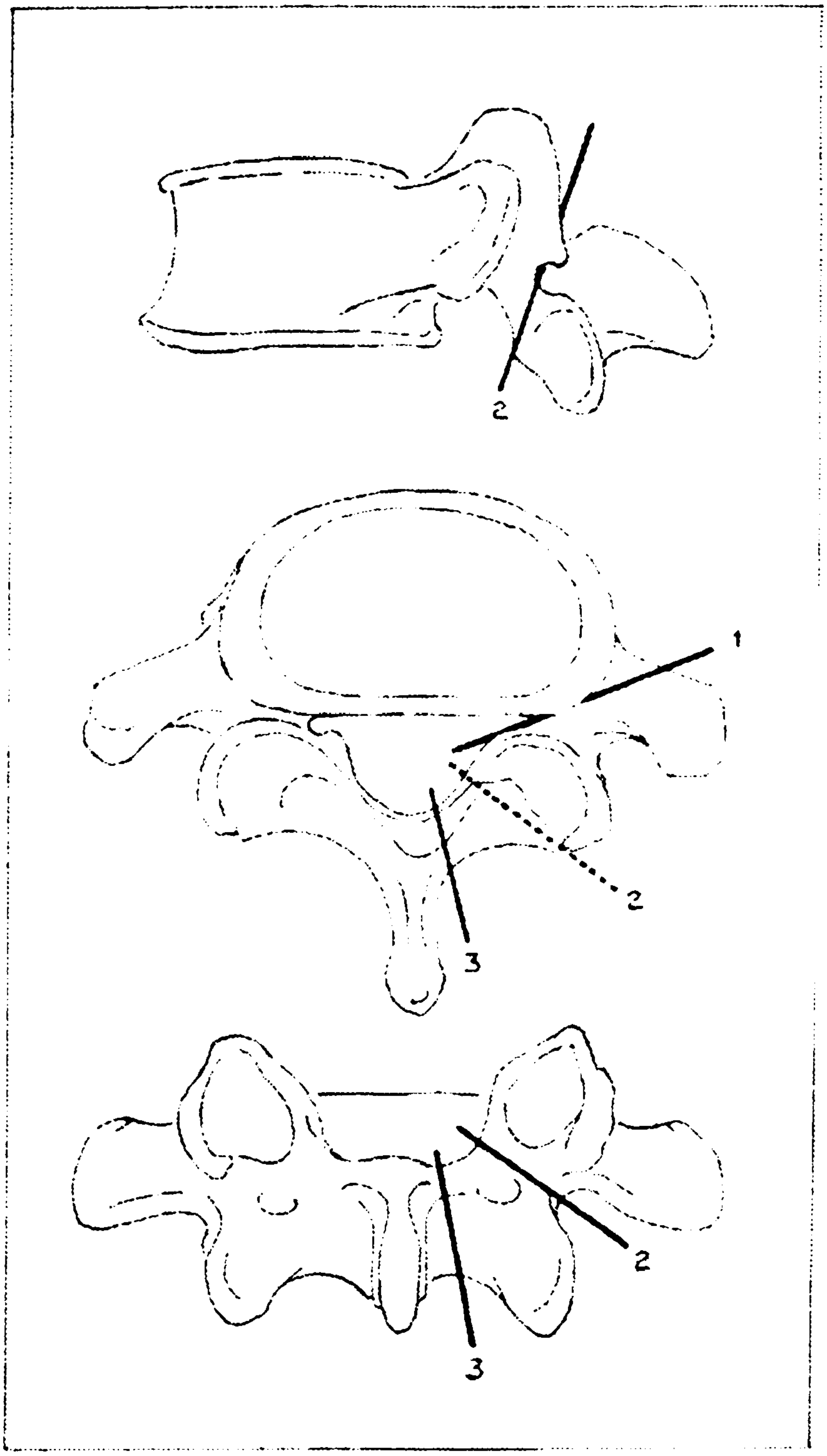

Figure 5. The three most common locations of spondylolysis. (1) Pedicle; (2) *Pars interarticularis*; (3) Lamina. Drawing by Robert Lane.

1978; Cyron et al., 1976; Hadley, 1963; Hensinger, 1989; Münster and Troup, 1973). Third, spondylolysis may be the result of a combination of factors, including a genetic predisposition toward separation, and stress, which then induces lysis (Fredrickson et al., 1984; Hensinger, 1989; Kettelkamp and Wright, 1971; Merbs, 1983; Ortner and Putschar, 1985; Wiltse et al., 1976).

First is the idea that spondylolysis is caused by a developmental flaw in the ossification of the bone of the vertebral arch (Friberg, 1938; Krogman and Iscan, 1986; Willis, 1929, 1931). Hypoplasia of the lumbosacral junction also falls into this category of abnormal ossification (Saraste, 1985). It is thought that as the bone ossifies, there are areas that are more likely to exhibit this anomalous condition. Researchers have demonstrated that as the neural arch develops, it begins from one ossification center for each half of the arch then splits into three separate zones for the pedicle, lamina, and transverse process (Batts, 1939; Chandraraj and Briggs, 1991). Batts (1939) looked at 200 fetal spines in an attempt to determine the number of ossification centers of the neural arch. He found a single ossification center in each half of the arch in all but one individual, suggesting that multiple ossification centers are rarer than spondylolysis, and thus are not a good candidate for the cause of the condition (Batts, 1939). Chandraraj and Briggs (1991) found only one case of asymmetrical growth between the two halves of the arch, which they believe could possibly lead to a weakness at that point when an upright posture is adopted. There is no good evidence to support the argument that spondylolysis is a developmental defect as there is no developmental separation that corresponds to the location where spondylolysis most often occurs.

Spondylolysis is rare in children. Friberg (1938) found interarticular spondylolysis in all of the lumbar vertebrae of a ten-month-old child. The problem with this case, however, is that the child also exhibited a suite of other congenital deformities linked to heredity. Friberg (1938) believes this child provides good evidence for the hereditary nature of spondylolysis. Later researchers have established that spondylolysis is linked to heredity and familial studies indicate that the trait has an autosomal dominant mode of inheritance with possible incomplete penetrance (Haukipuro et al., 1978; Shahriaree and Harkess, 1970; Shahriaree et al., 1979; Wynne-Davis and Scott, 1979).

The second explanation for the etiology of spondylolysis is that it is a stress fracture related to heavy strains on the lower lumbar vertebrae (Cyron and Hutton, 1978; Cyron et al., 1976; Hadley, 1963; Hensinger, 1989; Ichikawa et al., 1982; Munster and Troup, 1973; Newman, 1963). The fifth lumbar vertebra (L5) supports the greatest amount of weight of all vertebrae when an individual is standing erect (Davis, 1961; Krenz and Troup, 1973). Because of the weight bearing responsibilities of L5, it would be expected that this vertebra is most often associated with these fractures. A key to this aspect is that spondylolysis has not been documented in nonambulatory patients (Rosenberg et al., 1981). Rosenberg et al. (1981) feel that this is the best evidence that spondylolysis is a result of fatigue fractures associated with bipedality. It should also be noted that spondylolysis seems to be a uniquely human trait among the primates (Wiltse, 1962). Therefore, an upright posture may be one of the keys to the etiology of this condition.

Early surgeons and researchers noted that spondylolysis was often associated with either trauma or heavy labor (Friberg, 1938; Kleinberg, 1934). Neural arch fatigue fractures were noted during training of new recruits during World War II (Newman, 1959). Newman observed that the most common cause was forced marches with heavy packs, and all responded well to rest with no operations necessary (Newman, 1959; Newman, 1963). Other researchers have performed specific fatigue strength analyses on the fourth and fifth lumbar vertebrae to test the strength of the neural arch in each (Cyron and Hutton, 1978; Cyron et al., 1976). Their findings, based upon a load similar to that of carrying a heavy pack with the weight alternating sides on the inferior articular facets, show that it is possible for spondylolytic fractures to occur in this manner. Additionally, they found that these fractures occur most often at the *pars interarticularis*, where spondylolytic fractures in skeletal samples are most commonly found (Cyron and Hutton, 1978; Cyron et al., 1976). Ichikawa et al. (1982) found that the incidence depends on the different ways in which loading on the spinal column occurs, when they examined spondylolysis among athletes involved in different sports. They divided the sports into three types of stresses on the back: axial, rotational, and bending. Their findings suggest that axial stresses account for the highest frequency of spondylolysis. It is also possible that the etiology is affected by specific vertebra as well. Saraste (1985) found that trauma was most often associated with lysis of the neural arch of the fourth lumbar vertebra (L4), suggesting the possibility of different etiologies for spondylolysis on different vertebrae.

Finally, it has been suggested that spondylolysis is caused by a combination of factors. These include a genetic predisposition toward the anomaly, with stress (or fatigue) as an activating mechanism that induces lysis (Frednckson et al., 1984; Hensinger, 1989; Kettelkamp and Wright, 1971; Merbs, 1983; Ortner and Putschar, 1985; Stewart, 1956; Wiltse et al., 1975). The higher frequency of spondylolysis in certain populations suggests genetic and behavioral factors may be present, although there is no way to test this hypothesis (Merbs, 1995; Simper, 1986). Frednckson et al. (1984) believe there is a genetic predisposition toward spondylolysis based on a radiographic study of first-grade school children; although, the results of their study were not clear.

Saraste (1985) also sees a hereditary etiology for spondylolysis, but only for L5 as based on observed differences in the frequency of trauma associated with the onset of symptoms. She found that trauma precedes symptoms in 54% (n = 13) of cases involving spondylolysis of L4, while only 22% (n = 30) of the cases of L5 spondylolysis are associated with trauma. Saraste (1985) concludes that there is a significant difference between the frequency of trauma before spondylolysis on L4 and L5. Therefore, she believes that differential frequencies in occurrence are evidence for different etiologies depending on which vertebra is involved. Kettelkamp and Wright (1971) performed a clinical survey of patients identified as northern Eskimos admitted to a Native hospital in Anchorage, Alaska for non-back related problems. They acquired x-rays of the lumbar spine for 153 individuals from villages north of the Yukon River and examined them for spondylolysis. The anomaly was observed in 28% of the individuals in their sample. Kettelkamp and Wright feel their observations support the claims of other researchers for a genetic basis to the etiology of spondylolysis, although they did not perform a similar clinical survey of southern Eskimos for comparison.

Acute trauma as an etiology for spondylolysis must also be considered. This would be very difficult to discern in an archaeological context given the poor preservation of vertebral elements in most instances. However, it appears that acute traumatic spondylolysis is a rare occurrence (Cope, 1988).

Spina bifida occulta

Spina bifida involves incomplete closure of the lamina of the vertebral arch which allows portions of the spinal chord to push through the opening (Thomas, 1981). The condition is often divided into two forms, *spina bifida cystica* and *spina bifida occulta*. *Spina bifida cystica* generally involves the protrusion of the spinal cord and meninges, and may result in stillbirths, paralysis, or early mortality (Flood et al., 1992). *Spina bifida occulta* is the incomplete fusion of one or more spinous processes that is not associated with protrusion of the spinal chord and is especially common in the sacral area (Ortner and Putschar, 1985). In skeletal collections it is only feasible to concern ourselves with the latter, because we cannot know whether or not soft tissues were affected by the defects in the bone. In fact, it has been argued that in archaeological collections if spina bifida is observed in an adult skeleton, we can assume the condition was *spina bifida occulta* (Morse, 1978).

The etiology of *spina bifida occulta* is only slightly clearer than that for spondylolysis. The spinous processes of the lower lumbar vertebrae and sacrum fuse between the ages of four and six years of age (Schmorl and Junghanns, 1971), and there has been a great deal of evidence collected suggesting *spina bifida occulta* is age related. Others have argued that it is a congenital disorder with a strong genetic link (Ortner and Putschar, 1985; Thomas, 1981). It has even been argued that *spina bifida occulta* may be associated with geographical location, socioeconomic status, and even birth order (Post, 1966), although a great deal more research needs to be done to confirm this. McKusick et al. (1992) found that spina bifida most closely resembles an autosomal dominant trait, with a high probability of penetrance. Many researchers believe that *spina bifida occulta* and spina bifida cystica are simply different expressions of the same genes (Lorber and Levick, 1967; McKusick, 1992). This has been contested by researchers who see the differences in survivability of individuals with either condition as evidence for different controlling genes (Miller et al., 1962). Others have speculated that *spina bifida occulta* has a multifactorial etiology that includes genetics and environmental stimuli; although, the environmental triggering mechanisms have yet to be determined (Carter, 1969; Laurence, 1967).

Schmorl's nodes

Schmorl's nodes are named for Christian Georg Schmorl, an early 1900s German pathologist who was interested in spinal pathologies (Anderson et al., 1994). A Schmorl's node occurs as a result of a vertical intervertebral disc herniation, in which the nucleus pulposus penetrates the body of the adjoining vertebra, either above or below (Capasso et al., 1999).

The major stress factor involved in the formation of a Schmorl's node is flexion and lateral bending of the vertebral column, usually associated with lifting heavy objects (Capasso et al., 1999). An initial acute stress may cause the herniation of the intervertebral disc, but the continuation of that same activity results in the bone remodeling observed in skeletal collections.

Osteoarthritis/Degenerative Joint Disease

Osteoarthritis or degenerative joint disease (DJD) is one of the most common of all bone diseases in humans (Wells, 1964). Key factors associated with the etiology of osteoarthritis are age and physical activity (Bridges, 1992). Within the spine, osteoarthritis can be produced in a number of ways, including intervertebral disc degeneration and disturbance of spinal ligaments (Aufderheide and Rodríguez-Martín, 1998). In addition to osteoarthritic remodeling, degenerative disc disease (DDD), or vertebral osteochondrosis, can also be responsible for vertebral compression fractures (Merbs, 1989).

Interpretations regarding the prevalence of osteoarthritis are made difficult by the subjective nature of the scoring techniques applied (Bridges, 1992). Stewart (1947) pointed to the patterning of lesions and differences in these patterns between distinct population groups as reflecting cultural differences. He also suggested there may be a racial (genetic) component. Bridges (1992) believes that patterning of arthritis with subsistence economy provides inconsistent results, and points to the many similarities in osteoarthritis patterning between groups with distinctly different subsistence backgrounds. Eskimos seem to exhibit high frequencies of osteoarthritis of the upper extremities (Jurmain, 1977; Merbs, 1983; Ortner, 1968). In Merbs' (1983) examination of the Sadlermiut, he found that the characterization of osteoarthritis within the population was difficult at best, with very few patterns of osteoarthritic development observed. He was able to make only a few generalizations regarding osteoarthritis frequencies: (1) males show a higher frequency and a greater degree of involvement than do females; (2) the right side is more often affected; and (3) the upper extremities are more often affected than are the lower (Merbs, 1983).

According to Bridges (1992), the asymmetry observed by Merbs is common, at least in the shoulder and elbow for most Native American populations examined. Bridges (1992) also claims that numerous behavioral and social changes can have an effect on frequencies of osteoarthritis, including increased warfare causing traumatic arthritis, decreased mobility, and even an increase in social complexity. All of these factors make the characterization of osteoarthritis in Native Alaskan skeletal populations difficult. The application of statistics to isolate patterns of osteoarthritis within a population, as Merbs did with the Sadlermiut, appears to be one of the most useful ways of analyzing osteoarthritis frequencies. The lack of good comparative data among populations needs to be addressed before larger generalizations can be attempted for patterns of osteoarthritis.

Sacralization of L5/L6 and Lumbarization of the sacrum

The lumbosacral junction is where the most frequent anomalous variations of vertebrae occur (Schmorl and Junghanns, 1971; Todd, 1922; Willis, 1929). Sacralization of the L5/L6 is described as a change in the structure of the last lumbar vertebra toward the shape of the first piece of the sacrum (Lanier, 1939). Sacralization may be divided into two categories, complete and incomplete. Complete sacralization refers to the total incorporation of the last lumbar vertebra into the sacrum, leaving only 23 presacral vertebrae (unless there is an L6 involved) (Lanier, 1939). Incomplete sacralization is where the last lumbar vertebra retains some features that clearly distinguish it as a lumbar vertebra (Schmorl and Junghanns, 1971). Ortner and Putschar (1985) report that sacralization of the fifth lumbar vertebra is common in skeletal populations, but they provide no comparative data on its occurrence.

Lumbarization of the sacrum refers to either complete or partial separation of the first sacral segment (S1) from the rest of the sacrum (Schmorl and Junghanns, 1971). As with sacralization, there is a wide range of intermediate stages between partial and complete separation. Several researchers (Aufderheide and Rodríguez-Martín, 1998; Lanier, 1954; Schmorl and Junghanns, 1971; Schultz and Strauss, 1945) contend that without the complete vertebral column it is nearly impossible to distinguish between sacralization of L5/L6 and lumbarization of S1. Because of this problem, Schmorl and Junghanns (1971) state that data on lumbarized and sacralized vertebrae are highly suspicious. They recommend combining the two forms of vertebrae into a general transitional category.

In the past, the term "transitional lumbosacral vertebra" has generally been in reference to numerical variation in the number of vertebral elements in humans (Bornstein and Peterson, 1966; Lanier, 1939; Willis, 1923). With respect to this, some researchers have noted significant increases in the number of precaudal vertebral elements in males for several populations around the world (Bornstein and Peterson, 1966; Merbs, 1974).

The etiology of transitional lumbosacral vertebrae is unclear, although there is evidence that it may be genetic in origin, with a possible relationship to *spina bifida occulta* (Bennett, 1972). One researcher emphasized mechanical stress as the major factor in lumbosacral fusion (Thieme, 1951), but this idea was later rejected. The more accepted view is that such fusion is a congenital defect that is genetic in origin (Lanier, 1954). Lanier (1954) does list pathological conditions associated with osteoarthritis and other diseases as causes of fusion, but he states that, while these are clinically significant, they are not anatomically significant.

Presacral Vertebral Fusion

Vertebral fusion not associated with the lumbosacral region is an anomaly that has been given less attention than have those listed above. Fusion of this type falls into two main categories, congenital and pathological. The most common type of vertebral fusion is the result of pathological conditions that stimulate osteophyte development (Schmorl and Junghanns, 1971). Fusion of the vertebral column in skeletal populations has also been attributed to Klippel-Feil syndrome (Ortner and Putschar, 1985). Klippel-

Feil syndrome involves congenital fusion of two or more cervical vertebrae into a solid block (Aufderheide and Rodríguez-Martín, 1998). The etiology of this condition is believed to be genetic, although the exact method of heredity has not been determined (Aufderheide and Rodríguez-Martín, 1998). Block vertebrae that are congenital in origin are not actually fused, but rather they failed to separate in the developing vertebral column (Barnes, 1994).

Pathological fusion of multiple vertebrae has also been observed in cases of diffuse idiopathic skeletal hyperostosis (DISH), ankylosing spondylitis, and rheumatoid arthritis. All three conditions can be similar in appearance in skeletal collections, making specific diagnosis problematic. DISH is characterized by ligament ossification of the spine, without the involvement of the intervertebral discs (Resnick and Niwayama, 1976). The result is bony bridges connecting adjacent vertebrae with the look of "dripping candle wax" (Forestier and Lagier, 1971). Recently, some researchers have questioned the lack of association between degenerative disc disease and DISH (di Girolamo et al., 2001). DISH has been reported in numerous skeletal collections from around the world (Arriaza et al., 1993; Crubézy and Trinkaus, 1992). The exact etiology of the condition is still open for debate, although it does appear to be age related in most cases (Aufderheide and Rodríguez-Martín, 1998).

Ankylosing spondylitis is very often confused with DISH (Aufderheide and Rodríguez-Martín, 1998). Ankylosing spondylitis usually involves degeneration of the sacroiliac joint followed by vertebral fusion through bony ankylosis of the diarthrodial joints, eventually leading to calcification of the spinal ligaments (Aufderheide and

Rodríguez-Martín, 1998; Ortner and Putschar, 1985). The disease itself is progressive in its involvement of the spine and does affect the intervertebral discs (Ortner and Putschar, 1985). The etiology of this condition is also in question; however, it has been linked to the histocompatibility complex antigen HLA-B27, which suggests a genetic component (Aufderheide and Rodríguez-Martín, 1998). It also appears that ankylosing spondylitis is related to sex, with a much higher frequency of males affected (Aufderheide and Rodríguez-Martín, 1998; Ortner and Putschar, 1985). Ankylosing spondylitis has been well documented in collections from all over the world including other samples from Alaska (Ortner and Putschar, 1985). In a few rare cases ankylosing spondylitis and DISH occur in the same individual, although there is still some debate regarding the relationship of the two pathologies (De Vlam et al., 1996; Tishler and Yaron, 1992).

Rheumatoid arthritis differs from both DISH and ankylosing spondylitis in the initial involvement of the joints of the hands (Ortner and Putschar, 1985). It involves progressive, systematic arthritic changes throughout the skeleton, but most often seen in the hands, elbows, shoulders, knees, and feet (Aufderheide and Rodríguez-Martín, 1998; Ortner and Putschar, 1985). Vertebral involvement is usually associated with late stage development of the disease (Ortner and Putschar, 1985). Rheumatoid arthritis appears to occur most often in females, and is seen in both juvenile and adult forms (Ortner and Putschar, 1985). The etiology of rheumatoid arthritis, like DISH and ankylosing spondylitis, is also unclear. It is believed to be associated with genetic, climatic, and possibly even infectious agents (Aufderheide and Rodríguez-Martín, 1998; Ortner and Putschar, 1985).

There have been relatively few cases of vertebral fusion that can conclusively be determined to be congenital. In fact, one researcher has stated that congenital fusion of the atlas to the axis is most likely one of the rarest of all congenital vertebral anomalies (Cave, 1930). One reason that so few vertebrae are classified as congenitally fused, is that unless the condition is found while the individual is relatively young, the fusion itself will cause arthritic buildup on the surrounding vertebrae that are compensating for the lack of movement. It is then nearly impossible to determine which came first, the fusion or the arthritis. In the following analysis, all vertebral fusion, whether congenital or pathological, will be discussed.

Fractures and wedging

Vertebral fractures that are not spondylolytic in nature are generally associated with acute trauma. Furthermore, acute traumatic fractures are often separated analytically from compression fractures, where a collapse of the vertebral body is noted. Compression fractures are often associated with falls or sharp vertical forces applied to the vertebral column, such as when riding in a sled or cart over rough terrain (Merbs, 1989). There may be many causes for a fracture, including thinning of the bone associated with osteoporosis or a general weakening of the bone as a result of infection. Several diseases and infections affect the bone density of vertebral bodies. Tuberculosis affects the vertebral bodies through the destruction of the trabecular bone, which can lead to the collapse of the vertebral body through trauma (Ortner and Putschar, 1985). Lesions similar to those of tuberculosis are observed in association with the fungal infection coccidioidomycosis, although this disease is generally restricted to warm arid regions (Aufderheide and Rodríguez-Martín, 1998). Similarly, blastomycosis is another fungal infection that can cause destructive lesions of the spine leading to vertebral body collapse (Morse, 1978). It is generally isolated in the cooler regions of North America, including the upper Midwest and mid-Atlantic regions of the United States (Aufderheide and Rodríguez-Martín, 1998).

The exact causative agent involved in the trauma can rarely be defined from dry bones; however, the resultant effect on the bone can be described. From these descriptions it is then possible to characterize the overall pattern of traumatic vertebral fractures within a population.

METHODS AND MATERIALS

The skeletal collections analyzed in the present study were collected during the late 19th and early 20th centuries, the vast majority of which were collected by Henry B. Collins and T. Dale Stewart for the Smithsonian Institution (Collins, 1927; Hrdlička, 1930; Speaker et al., 1996). There are at least 165 individuals in the Golovin Bay collection and 139 individuals in the Nunivak collection. While it is difficult, if not impossible, to accurately date the skeletal remains in each collection, it was noted that the majority of the remains from Nunivak Island most likely dated to the late 19th and early 20th centuries (Speaker et al., 1996). The most common "bone" in both collections is the cranium. Most individuals do not include complete vertebral columns, due, no doubt, to both the biases of the collectors' era and the lack of preservation of vertebrae in the archaeological record. There are more vertebrae in the Golovin Bay collection than the Nunivak Island collection (see Appendices B and C); nevertheless, there are many vertebrae from both collections from which analysis is possible.

All vertebrae were observed and documented utilizing the Smithsonian protocol for skeletal analysis (Verano and Ureid, 1994). This protocol was developed by the Repatriation Office of the National Museum of Natural History at the Smithsonian Institution. One of the main tasks of the Repatriation office is to assess the cultural affiliation of both human remains and funerary objects housed at the National Museum of Natural History. The protocol for skeletal analysis is simply a tool for the inventory and description of human remains. As such, it is limited in the recording potential for numerous pathological conditions (see Conclusions section for specific problems). Nevertheless, the data collected using this protocol are useful for comparing collections using statistical analyses of frequencies of occurrence of various traits. I have tried to take all of the limitations of the data set into consideration in the following analysis. The age and sex of each individual is estimated using criteria set forth in the protocol. Age categories described below are given in Table 3. The specific materials used in the analysis of each condition observed are provided below.

Table 3. Age category descriptions

Age	Description
NB - .9 yrs	Newborn
1 – 4 yrs	Young child
5 – 9 yrs	Child
10 – 14 yrs	Adolescent
15 – 19 yrs	Late adolescent
20 – 34 yrs	Young adult
35 – 49 yrs	Middle adult
50 + yrs	Old adult

Spondylolysis

Recording methods

Spondylolysis was scored as either present or absent, bilateral or unilateral, and when present, by location on the vertebral arch (i.e. *pars interarticularis*, lamina, pedicle). All vertebrae with unilateral or bilateral spondylolysis are considered affected. Frequencies of spondylolysis are determined for each individual vertebra for males and females in each population. Subadults are left out of all subsequent analysis of spondylolysis because the extremely small samples from each population make statements regarding the presence or absence of spondylolysis in these populations impossible. Whenever possible, data used for comparison are from adults only. Comparison data often did not include analysis by individual vertebra, and frequencies of spondylolysis in those data sets are determined only from individuals with a complete set of lumbar vertebrae (L1-L5). Therefore, the frequency of spondylolysis is calculated for both Golovin and Nunivak samples in this way as well.

Golovin Bay materials

There are a total of 214 lumbar vertebrae from a minimum of 45 adults in the Golovin Bay collection, excluding transitional lumbosacral vertebrae. Of the remains with vertebrae, 34 individuals have complete lumbar segments (L1-L5), including 12 males and 22 females. Two individuals are excluded from the analysis of spondylolysis. The first has a complete set of lumbar vertebrae, but is classified as a probable female of an indeterminate age. The second individual, listed as indeterminate age and ambiguous sex, includes a single lumbar vertebra (L5) that exhibited spondylolysis. Because of the uncertain classifications, these individuals are excluded from further analysis, bringing the total number of observable vertebrae to 208 (Table 4).

Table 4. Lumbar vertebrae counts for Golovin and Nunivak.

	Golovin		Nunivak	
	Male	**Female**	**Male**	**Female**
L1	16	24	13	13
L2	15	25	12	12
L3	17	27	12	11
L4	16	26	12	12
L5	17	25	10	13
Totals	81	127	59	61

Nunivak Island materials

There are 122 lumbar vertebrae from a minimum of 26 adult individuals in the Nunivak Island collection. Twenty of the 26 have complete lumber segments, including nine males and 11 females. One individual, with L4 and L5 present, is classified as an adult of indeterminate sex. Because of the uncertain categorization, this individual is excluded from further analysis, bringing the total number of observable vertebrae to 120 (Table 4).

Spina bifida occulta

Recording methods

Spina bifida occulta was not observed in any presacral vertebral elements in either collection. All sacral elements were examined for incomplete union of the two halves of the neural arch. If any incomplete union is present, regardless of the number of sacral elements involved, it is recorded as affected for *spina bifida occulta*. The frequencies of spina bifida for males and females, as well as for the different age groups, are then calculated. There are inconsistencies in the original data set for Golovin Bay regarding partial sacra and whether or not they were observable for spina bifida; therefore, only complete sacra are utilized.

Golovin Bay materials

There are 46 complete sacra in the Golovin collection represented by 21 males, 20 females, and five unsexed subadults. Ages range from 1-4 years old to adults of more than 50 years (Table 5). Subadults are only represented by one individual in the 1-4 year age range, two individuals in the 10-14 year range, and two late adolescents aged 15-19 years.

Nunivak Island materials

The Nunivak Island collection contains complete sacra from 19 individuals ranging in age from late adolescent, 15-19 years old, to adults, 35 to 49 years of age. There are no sacra from children under 15 or adults older than 50 years. This group includes six males, ten females, two subadults, and one individual classified as a probable male adult of indeterminate age (Table 5). Because of the difficulties associated with both age and sex classification, this last individual was excluded from further analysis.

Table 5. Sacra counts for Golovin and Nunivak.

	Golovin		**Nunivak**	
Age category	**Subadults (not sexed)**		**Subadults (not sexed)**	
1 – 4 years	1		0	
10 – 14 years	2		0	
15 – 19 years	2		2	
Adults	**Male**	**Female**	**Male**	**Female**
20 – 34 years	6	8	3	2
35 – 49 years	14	10	3	8
50 + years	1	2	0	0
Totals	21	20	6	10

Schmorl's nodes

Recording methods

All vertebrae, with the exception of the first cervical vertebrae, were examined for intervertebral disk herniations. Lesions on the body of the vertebrae range from small depressions to grooves extending over a large area of the centrum. Some lesions even penetrate the outer table of bone, extending into the trabecular bone of the body. Any vertebra exhibiting these lesions was recorded as having a Schmorl's node present, regardless of the extent or number of lesions. Because of the timing of fusion of the vertebral body epiphyses, no subadult vertebrae are utilized for determination of the frequency of Schmorl's nodes in either population. Frequencies of occurrence are calculated using individual vertebrae because of the lack of complete vertebral columns.

Golovin Bay and Nunivak Island materials

There are 935 vertebrae in the Golovin collection observable for Schmorl's nodes, including 361 from males and 574 from females. These can be further broken down by vertebral segment (Table 6). The Nunivak Island collection contains 521 vertebrae. These include 255 from males and 266 from females (Table 6).

Osteoarthritis/Degenerative Joint Disease

Recording methods

All vertebrae were observed for the presence or absence of porosities associated with degenerative arthritis of the diarthrodial, amphiarthrodial, and costovertebral joints. Inconsistencies were found in the database in the recording of vertebral osteophytosis and vertebral arthritis. In many cases there was no separation of age related osteophytosis from activity related osteoarthritis. Therefore, spinal osteophytosis (*spondylitis deformans*) is also placed into this category, although the relationship to arthritic degeneration is sometimes questionable. A major limitation of the recording protocol is that there is no distinction made in the recording of degenerative disc disease versus degenerative joint disease. All vertebrae with porosities or degenerative remodeling around any of the joint surfaces are considered to be affected for osteoarthritis. The causal agent for the condition (i.e. trauma, disc herniation) is not taken into consideration during the scoring process. Frequencies of occurrence are calculated using individual vertebrae because of the lack of complete vertebral columns.

Table 6. Vertebra counts by segment for Golovin Bay and Nunivak Island.

	Golovin		**Nunivak**	
	Male	**Female**	**Male**	**Female**
Cervical	97 (82)	159 (134)	66 (55)	76 (63)
Thoracic	198	314	141	142
Lumbar	81	126	59	61
Totals	376 (361)	599 (574)	266 (255)	279 (266)
Numbers in ( ) represent counts without C1.				

Golovin Bay and Nunivak Island materials

There are 975 vertebrae in the Golovin collection examined for osteoarthritis. These include 376 from males and 599 from females (Table 6). In the Nunivak Island collection, there are 545 vertebrae observable for osteoarthritis. These include 266 from males and 279 from females (Table 6).

Transitional lumbosacral vertebrae

The lumbosacral junction in the human vertebral column is the most variable with regard to border shifting between vertebral types (Barnes, 1994). Without an intact lumbar region, or even a complete vertebral column, it may be impossible to determine whether what is being observed is sacralization of L5/L6 or lumbarization of S1 (Lanier, 1954; Schmorl and Junghanns, 1971). Lanier (1954) suggests that any vertebra fused at the lumbosacral junction be classified as a sacral unit. This type of classification may be useful for determining cranial and caudal shift in individuals, where the entire vertebral column is intact, but it is not a useful criteria for analyzing the amount of either lumbarization or sacralization in a skeletal collection that is less than complete. It is not typically possible to determine the exact number of presacral vertebrae, or even lumbar vertebrae, in skeletal samples from archaeological sites. Thus, the classification of a lumbar vertebra that has taken on some characteristics of the sacrum or a sacral segment that has been separated from the rest of the sacrum becomes extremely difficult.

Because of the scarcity of complete vertebral columns in either skeletal collection presented here, all vertebrae that are lumbarized or sacralized are classified as transitional lumbosacral vertebrae, as per Schmorl and Junghanns (1971). These include all fifth and sixth lumbar vertebrae that are partially or completely fused to the sacrum, and those that may be separated from the sacrum but have taken on the morphology of a sacral element. Also included as transitional lumbosacral vertebrae are all first sacral elements that have morphological characteristics resembling lumbar vertebrae, regardless of the total number of elements in the sacrum.

Presacral fused vertebrae

All fused vertebrae found above the lumbosacral junction are noted and described according to which vertebrae are involved and the portions of the vertebrae fused. Vertebral fusion at the lumbosacral junction is included in the category of transitional lumbosacral vertebrae; therefore, only fused vertebrae occurring outside of the sacral region are included in this particular analysis (i.e. no fused coccygeal vertebrae and no transitional lumbosacral vertebrae). Where possible, an attempt is made to ascertain the etiology of the fusion in each case, such as congenital versus traumatic, in order to better describe the nature of this condition in each collection.

Fractures and wedging

Any vertebral fractures or wedging observed in either population is noted. Vertebral body fractures are divided into several categories including compression, single end-plate depression without wedging, single end-plate depression with wedging, wedged (congenital/idiopathic only), and biconcave bodies with or without wedging (reflecting osteoporosis or osteomalacia) (Ureid and Byrd, 1995). Frequencies for fractures based on sex and age are calculated, and an attempt is made to characterize the pattern of this condition in each collection for age, sex, and location in the vertebral column.

Statistical analysis

Frequencies for the occurrence of each condition are calculated for males and females, and for different age groups for both skeletal samples. Following the recommendations of Sokal and Rohlf (1995) for analyzing 2 x 2 tables for independence, the G-test was chosen as the test statistic in this analysis. G-tests for independence are performed to determine whether or not differences in frequencies, both within and between the two skeletal collections, were statistically significant. The assumptions for the G-test of independence are the same as for chi-square test for independence (Sokal and Rohlf, 1995). These assumptions are that the data are sampled randomly, that it follows a multinomial distribution, it is categorical, and the frequencies are independent (Madrigal, 1999; Sokal and Rohlf, 1995). I have addressed the problems associated with random sampling in the introduction (see page 4). The other two assumptions are met in the two collections under study.

When using the G-test for contingency tables, the type I error is larger than expected and a correction value is calculated. Several correction formulas are available; the Williams correction is chosen here, as it tends to be more conservative (Sokal and

Rohlf, 1995). All resulting values are compared to the critical values of the chi-square distribution with the appropriate degrees of freedom. All formulas for the G-test were taken from Sokal and Rohlf (1995). For an example calculation of the G-test please see Appendix D.

RESULTS

Spondylolysis: Golovin Bay

There are 24 individuals in the Golovin Bay collection that exhibit spondylolysis on at least one vertebra. Of those, seven have spondylolysis on more than one vertebra, including three individuals with lysis of two, and four with lysis of three vertebrae (Figure 6). There are 35 vertebrae with spondylolysis, although only 32 may be utilized. The three vertebrae that are not used include one that is not clearly recognizable as either a fourth or fifth lumbar, one sixth lumbar with bilateral lysis through *pars interarticularis*, and one fifth lumbar with bilateral lysis through *pars interarticularis* from an adult of unknown age and sex. There is also one case of a separated neural arch on a first thoracic vertebra (T1) of a young adult female (AMNH# 352387A). This case is unusual because there is no clear evidence of trauma, and because the etiology of this particular condition is unknown.

The overall frequency of spondylolysis in the Golovin Bay collection, when considering only those individuals with complete lumbar segments, is 54.5% (n = 33) (Table 7). The frequency of spondylolysis is independent of sex ($P > 0.2$) in this collection. When spondylolysis is considered by each individual vertebra, the fifth lumbar vertebra exhibits the highest incidence in both males and females, at 52.9% (n = 17) and 32.0% (n = 25) respectively (Table 8). It occurs next most commonly on the fourth lumbar, with frequencies of 18.7% (n = 16) in males and 30.8% (n = 26) in females. The difference in frequency of spondylolysis between L4 and L5 in males is statistically significant ($P < 0.05$), while there is no significant difference between L4 and L5 frequencies in females ($P > 0.9$).

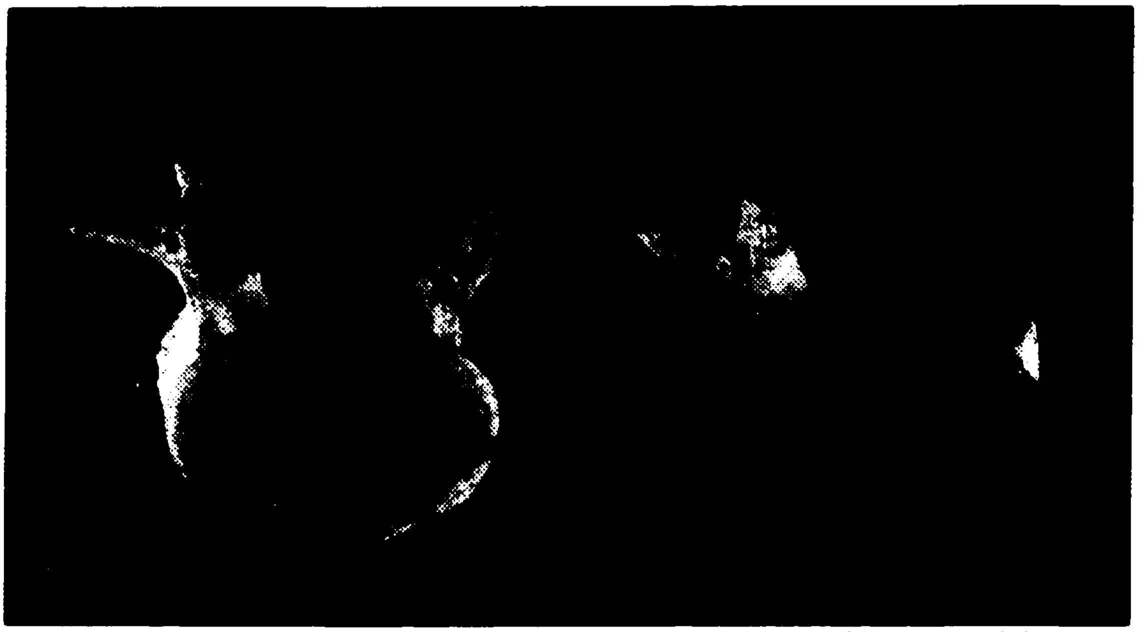

Figure 6. Spondylolysis of the fourth and fifth lumbar vertebrae of a middle adult female (AMNH #352408) from Golovin Bay, Alaska.

Spondylolysis: Nunivak Island

Only one individual in the Nunivak Island collection exhibits spondylolysis. The individual is classified as a middle adult male (AMNH# 339108) with spondylolysis of L2 through *pars interarticularis*. The frequency of spondylolysis at Nunivak Island, when considering only individuals with complete lumbar regions, is 5% (n = 20). This frequency is significantly different from that seen in the Golovin collection ($P < 0.001$).

Table 7. Golovin Bay spondylolysis counts and frequencies for individuals with complete lumbar segments L1-L5.

	Male			Female			Overall		
Age category (yrs)	**L1-L5[a]**	**Spond[b]**	**%**	**L1-L5**	**Spond**	**%**	**L1-L5**	**Spond**	**%**
20 – 34	4	2	50.00	8	2	25.00	12	4	33.33
35 – 49	7	5	71.43	10	6	60.00	17	11	64.71
50 +	1	1	100.00	3	2	66.67	4	3	75.00
Totals	12	8	66.67	21	10	47.62	33	18	54.55

[a] Number of individuals with complete L1-L5.

[b] Number of individuals with complete L1-L5 and spondylolysis.

Table 8. Individual lumbar vertebra spondylolysis counts and frequencies for Golovin Bay.

	Male			Female			Overall		
Vert	**n**	**Spond [a]**	**%**	**n**	**Spond**	**%**	**n**	**Spond**	**%**
L1	16	0	0.00	24	1	4.17	40	1	2.50
L2	15	0	0.00	24	1	4.17	39	1	2.56
L3	17	2	11.76	27	0	0.00	44	2	4.55
L4	16	3	18.75	26	8	30.77	42	11	26.19
L5	17	9	52.94	25	8	32.00	42	17	40.48

[a] Spondylolysis

***Spina bifida occulta*: Golovin Bay**

There are six individuals in the Golovin collection with *spina bifida occulta*, including two middle adult males, one late adolescent listed as a probable male, one young adult female, and two old adult females (Figure 7). One of the old adult females (AMNH# 346029) has only a partial sacrum, and although spina bifida is observable on this individual, it is not included because of inconsistencies in the original data set from Golovin Bay regarding whether or not the condition is observable on other partial sacra. Three individuals show completely open sacral canals, while the other two exhibit incomplete fusion of only a portion of the median crest.

There is no significant difference in the occurrence of *spina bifida occulta* based on sex ($P > 0.5$) or age ($P > 0.5$). *Spina bifida occulta* is seen in 9.5% (n = 21) of adult males and 10.0% (n = 20) of adult females in the Golovin collection. The overall frequency including males, females, and unsexed subadults is 10.9% (n = 46).

Some researchers have suggested a possible genetic link between spondylolysis and *spina bifida occulta* (Fredrickson et al., 1984). A G-test for independence of spina bifida from spondylolysis, in individuals with a complete sacrum and lumbar segment (L1-L5), indicates that the two are independent in this population ($P > 0.5$).

Figure 7. Complete *spina bifida occulta* in a middle adult male (AMNH #352394) from Golovin Bay, Alaska.

***Spina bifida occulta*: Nunivak Island**

Spina bifida occulta is present in three individuals with complete sacra in the Nunivak Island collection. These include two middle adult males with completely open sacral canals and one middle adult female with incomplete closure of the neural arches of the first two sacral elements (Figure 8). Frequencies in this collection are 33.3% (n = 6) for males and 10.0% (n = 10) for females. The overall frequency for all individuals with complete sacra, including unsexed subadults, is 16.7% (n = 18). Although the values for males and females are different, these differences are not statistically significant ($P > 0.1$). There is also no significant difference in the frequencies of *spina bifida occulta* between the Golovin Bay and Nunivak Island collections ($P > 0.5$).

The data collection protocol for Nunivak Island differed from Golovin Bay in that it included noting whether or not a sacrum was observable for *spina bifida occulta*. Therefore, frequencies of *spina bifida occulta* were also calculated for partial sacra that were observable for this condition. Utilizing these data, the observed frequencies are 21.1% (n = 15) for males, 6.3% (n = 15) for females, and 17.1% (n = 34) overall for adults and subadults (Table 9). Once again, there is no significant difference in the frequency of *spina bifida occulta* between males and females in the Nunivak collection when all observable sacra are included.

Figure 8. Partially open sacral canal in a young adult male (AMNH# 339107) from Nunivak Island, Alaska.

Table 9. Nunivak Island counts and frequencies of *spina bifida occulta* using all observable sacra.

	Male	Female	Subadult	Totals
Spina bifida	4	1	2	7
Normal	15	15	4	34
%	21.1	6.3	33.3	17.1

Schmorl's nodes: Golovin Bay

Twelve of 53 individuals in the Golovin collection exhibit Schmorl's nodes on at least one vertebra. Five of those individuals showed lesions on more than one vertebra, including one old adult female (AMNH# 346028) with lesions on five thoracic and four lumbar vertebrae. There were no lesions observed in any of the cervical vertebrae in this collection. The frequencies for the occurrence of Schmorl's nodes among individuals with at least one observable vertebra were 19.0% (n = 21) for males and 25.0% (n = 32) for females (Table 10). There is no difference ($P > 0.5$) in the overall frequency of Schmorl's nodes between the sexes. However, when broken down by vertebral segment, males (7.1%, n = 198) show a significantly higher frequency than females (2.9%, n = 314) in the thoracic vertebrae affected ($P < 0.025$). Females (10.3%, n = 126) exhibit a significantly higher frequency than males (2.5%, n = 81) in the lumbar vertebrae ($P < 0.025$) (Table 11). There is also an increase in the frequency of lesions with increased age in adults; however this increase is not statistically significant ($P > 0.05$) (Table 12).

Table 10. Presence of Schmorl's nodes for Golovin Bay and Nunivak Island among individuals with at least one observable vertebra.

	Male			**Female**			**Total**		
	n	**SN**[a]	**%**	**n**	**SN**	**%**	**n**	**SN**	**%**
Golovin	21	4	19.0	32	8	25.0	53	12	22.6
Nunivak	16	6	37.5	20	3	15.0	36	9	25.0

[a] Schmorl's nodes

Table 11. Counts and frequencies of Schmorl's nodes by vertebral segment for Golovin Bay.

	Male			**Female**			**Total**		
	n	**SN**[a]	**%**	**n**	**SN**	**%**	**n**	**SN**	**%**
Cervical[b]	82	0	0.0	134	0	0.0	216	0	0.0
Thoracic	198	14	7.1	314	9	2.9	512	23	4.5
Lumbar	81	2	2.5	126	13	10.3	207	15	7.2
All	361	16	4.4	574	22	3.8	935	38	4.1

[a] Schmorl's nodes; [b] C1 not included

Table 12. Frequencies of Schmorl's nodes by age category for Golovin Bay.

Age category (yrs)	n	SN[a]	%
20 – 34	21	2	9.5
35 – 49	27	7	26.0
50 +	5	3	60.0
Totals	53	12	22.6

[a] Individuals with Schmorl's nodes.

Schmorl's nodes: Nunivak Island

The Nunivak collection contains nine individuals with Schmorl's nodes on at least one vertebra (Table 10). Seven of the nine exhibit lesions on multiple vertebrae (Figure 9), including two middle adult males (AMNH#339160 & 339256) showing lesions on eleven vertebrae each. The overall frequency of Schmorl's nodes, in individuals with at least one observable vertebra, was 37.5% (n = 16) for males and 15% (n = 20) for females. This difference is not statistically significant ($P > 0.05$). When broken down by vertebral segment, the cervical vertebrae showed no significant difference in frequency between males (1.8%, n = 55) and females (1.6%, n = 63) ($P > 0.9$). Frequencies of lesions are significantly higher for males in both the thoracic ($P < 0.001$) and lumbar ($P < 0.005$) vertebrae (Table 13). In the thoracic region males exhibit a frequency of 15.6% (n = 141) while females only show the lesion 0.7% (n = 142) of the time. The lumbar vertebrae show a difference of 23.7% (n = 59) in males versus 3.3% (n = 61) in females. Although old adult individuals are underrepresented in this sample, it appears as if the frequency of Schmorl's nodes increases with age based on the significant increase in occurrence observed from young adults to middle adults (*P* < 0.025) (Table 14).

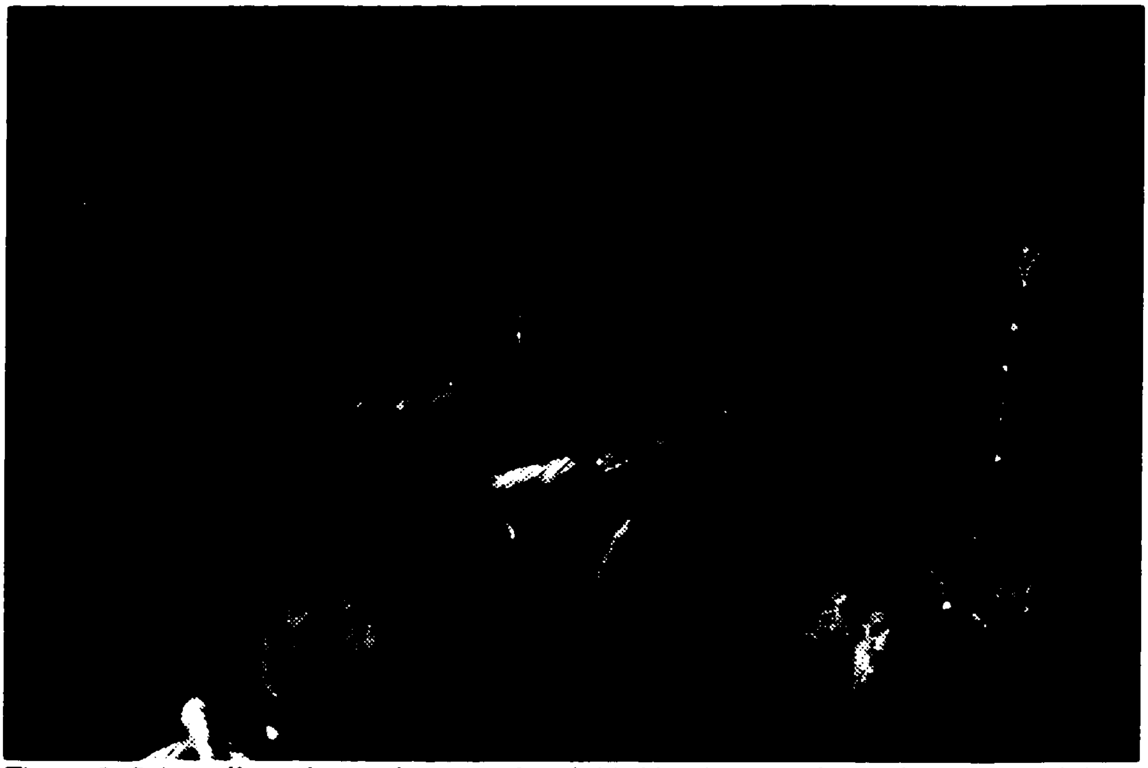

Figure 9. Schmorl's nodes on the second and third lumbar vertebrae of a middle adult male (AMNH #339256) from Nunivak Island, Alaska.

Table 13. Counts and frequencies of Schmorl's nodes by vertebral segment for Nunivak Island.

	Male			Female			Total		
	n	SN[a]	%	n	SN	%	n	SN	%
Cervical[b]	55	1	1.8	63	1	1.6	118	2	1.7
Thoracic	141	22	15.6	142	1	0.7	243	23	9.5
Lumbar	59	14	23.7	61	2	3.3	120	16	13.3
All	255	37	14.5	266	4	1.5	481	41	8.5

[a] Schmorl's nodes; [b] C1 not included

Table 14. Frequencies of individuals with Schmorl's nodes by age category for Nunivak Island.

Age category (yrs)	n	SN[a]	%
20 – 34	11	1	9.1
35 – 49	16	8	50.0
50 +	1	0	0.0
Totals	28	9	32.1

[a] Individuals with Schmorl's nodes

The overall frequencies of the occurrence of Schmorl's nodes based upon individuals with at least one observable vertebra are Golovin Bay (22.6%, n = 53) and Nunivak Island (25.0%, n = 36). These values are not significantly different ($P > 0.1$). Males at Nunivak Island have a higher frequency of lesions (37.5%, n = 16) than do males at Golovin (19.0%, n = 21), while females at Nunivak exhibit a lower frequency

(15.0%, n = 20) in comparison to females from Golovin (25.0%, n = 32). Neither of these differences are statistically significant.

Comparisons are made among the vertebral segments of each sample. The frequency of lesions based on individual observable vertebrae in males was significantly higher in the Nunivak sample than in the Golovin sample, for both the thoracic and lumbar segments (Table 15). When broken down by individual observable vertebrae in each segment, there is still no statistically significant difference between the females of the two groups (Table 16).

Table 15. Counts and frequencies of vertebrae with Schmorl's nodes by vertebral segment for Golovin Bay and Nunivak Island males.

	Golovin Males			Nunivak Males			*P* - value
	n	SN[a]	%	n	SN	%	
Cervical[b]	82	0	0.0	55	1	1.8	> 0.1
Thoracic	198	14	7.1	141	22	15.6	< 0.025
Lumbar	81	2	2.5	59	14	23.7	< 0.001
All	361	16	4.4	255	37	14.5	< 0.001

[a] Schmorl's nodes; [b] C1 not included

Table 16. Counts and frequencies of vertebrae with Schmorl's nodes by vertebral segment for Golovin Bay and Nunivak Island females.

	Golovin Females			**Nunivak Females**			***P* - value**
	n	**SN**[a]	**%**	**n**	**SN**	**%**	
Cervical[b]	134	0	0.0	63	1	1.6	> 0.1
Thoracic	314	9	2.9	142	1	0.7	> 0.1
Lumbar	126	13	10.3	61	2	3.3	> 0.05
All	574	22	3.8	266	4	1.5	>0.05

[a] Schmorl's nodes; [b] C1 not included

Osteoarthritis/Degenerative Joint Disease: Golovin Bay

Osteoarthritis is present in 46 of 53 individuals with at least one observable vertebra in the Golovin collection (Figure 10). Males (90.5%, n = 21) showed a higher frequency of osteoarthritis than females (84.4%, n = 32), though the difference is not significant. When broken down by vertebral segment, males and females show similar frequencies of osteoarthritis (Table 17), although males have consistently higher frequencies in each segment. The differences observed are only statistically significant in the thoracic vertebrae ($P < 0.05$). There is also a significant increase in the frequency of osteoarthritis with age in adults in this collection ($P < 0.05$) (Table 18).

Table 17. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Golovin Bay.

	Male			Female			Total		
	n	OA	%	n	OA	%	n	OA	%
Cervical	97	57	58.8	159	81	50.9	256	138	53.9
Thoracic	198	131	66.2	314	180	57.3	512	311	60.7
Lumbar	81	54	66.7	126	72	57.1	207	126	60.9
All	376	242	64.4	599	333	55.6	975	575	59.0

Table 18. Frequencies of osteoarthritis (OA)/DJD by age category for Golovin Bay.

	Male			Female			Total		
Age category (yrs)	n	OA	%	n	OA	%	n	OA	%
20 – 34	7	5	71.4	14	10	71.4	15	21	71.4
35 – 49	13	13	100	14	13	92.9	27	26	96.3
50 +	1	1	100	4	4	100	5	5	100

Osteoarthritis/Degenerative Joint Disease: Nunivak Island

Twenty-three of 36 individuals, with at least one observable vertebra, exhibit some form of osteoarthritis in the Nunivak Island collection. The frequency of osteoarthritis in males is 62.5% (n = 16), while females exhibit a slightly higher frequency of 65.0% (n = 20), but the difference is not significant ($P > 0.5$). Frequencies

Figure 10. Extreme osteophyte development on L1-L5 of a middle adult male (AMNH #352394) from Golovin Bay, Alaska.

of osteoarthritis, when observed by vertebral segment, show males with higher frequencies in the cervical and thoracic vertebrae, but females have a higher frequency in the lumbar vertebrae (Table 19). The differences between the cervical and lumbar frequencies in males and females are significant ($P < 0.025$), while the thoracic vertebrae are not ($P > 0.1$). Once again, although the sample size for the old adult age category (50 + years) is small, the differences in the frequencies of osteoarthritis in each age category are significant ($P < 0.005$) (Table 20).

Table 19. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Nunivak.

	Male			Female			Total		
	n	OA	%	n	OA	%	n	OA	%
Cervical	66	9	13.6	76	2	2.6	142	11	7.7
Thoracic	141	59	41.8	142	49	34.5	283	108	38.2
Lumbar	59	26	44.1	61	40	65.6	120	66	55.0
All	266	94	35.3	289	91	31.5	555	185	33.3

The frequency of osteoarthritis in adults at Golovin (86.8%, n = 53) is significantly higher than for adults at Nunivak (63.9%, n = 36) ($P < 0.025$). Males at Golovin (90.5%, n = 21) show a significantly higher frequency than do males at Nunivak (62.5%, n = 16) ($P < 0.025$), whereas among the females there is no significant difference ($P > 0.1$). When broken down by observable vertebrae in each segment, males at Golovin show higher frequencies of osteoarthritis throughout the vertebral column (Table 21). Females from Golovin Bay exhibit significantly higher frequencies of osteoarthritis in the cervical and thoracic segments of the vertebral column than do females from Nunivak Island (Table 22).

Table 20. Frequencies of osteoarthritis (OA)/DJD by age category for Nunivak.

	Male			Female			Total		
Age category (yrs)	**n**	**OA**	**%**	**n**	**OA**	**%**	**n**	**OA**	**%**
20 – 34	6	1	16.7	5	1	20.0	11	2	18.2
35 – 49	9	8	88.9	15	12	80.0	24	20	83.3
50 +	1	1	100	0	0	0	1	1	100

Table 21. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Golovin Bay and Nunivak Island males.

	Golovin Males			Nunivak Males			*P* - value
	n	**OA**	**%**	**n**	**OA**	**%**	
Cervical	97	57	58.8	66	9	13.6	< 0.001
Thoracic	198	131	66.2	141	59	41.8	< 0.001
Lumbar	81	54	66.7	59	26	44.1	< 0.001
All	376	242	64.4	266	94	35.3	< 0.001

Table 22. Counts and frequencies of osteoarthritis (OA)/DJD by vertebral segment for Golovin Bay and Nunivak Island females.

	Golovin Females			Nunivak Females			*P* - value
	n	OA	%	n	OA	%	
Cervical	159	81	50.9	76	2	2.6	< 0.001
Thoracic	314	180	57.3	142	49	34.5	< 0.001
Lumbar	126	72	57.1	61	40	65.6	> 0.1
All	599	333	55.6	289	91	31.5	< 0.001

Transitional lumbosacral vertebrae: Golovin Bay

There are 15 individuals in the Golovin Bay collection exhibiting transitional lumbosacral vertebrae (Table 23), including one individual classified as an adult of unknown age and sex (AMNH# 346131). The frequency of occurrence of transitional lumbosacral vertebrae is calculated using only those individuals with complete lumbar regions and sacra. Ten of the 15 individuals with transitional lumbosacral vertebrae meet this qualification, including six males and four females (Figure 11). The frequency of this condition in adults from Golovin Bay is 33.3% (n = 30) (Table 24). Although summary statistics regarding the frequency of this condition are difficult to interpret because of the incomplete nature of the sample, it appears that transitional lumbosacral vertebrae are not more common to either sex or a particular age group in the Golovin Bay collection.

Table 23. Transitional lumbosacral counts by age and sex for Golovin Bay.

Age category (yrs)	Male	Female	Total[a]
20 – 34	2	3	5
35 – 49	3	5	8
50 +	1	0	1
All	6	8	14

[a] Total does not include individual of unknown age and sex.

Table 24. Presence of transitional lumbosacral vertebrae for Golovin Bay and Nunivak Island among individuals a complete lumbar segment and sacrum.

	Male			Female			Total		
	n	TL[a]	%	n	TL	%	n	TL	%
Golovin	12	6	50.0	18	4	22.2	30	10	33.3
Nunivak	4	1	25.0	9	0	0.0	13	1	7.7

[a] Transitional lumbosacral vertebrae

Transitional lumbosacral vertebrae: Nunivak Island

The Nunivak Island collection contains only two individuals with transitional lumbosacral vertebrae (Figure 12), including one female (AMNH# 339147) and one male (AMNH# 339133), both classified as young adults. Only the male meets the criteria of having a complete lumbar region and an observable sacrum for use in the

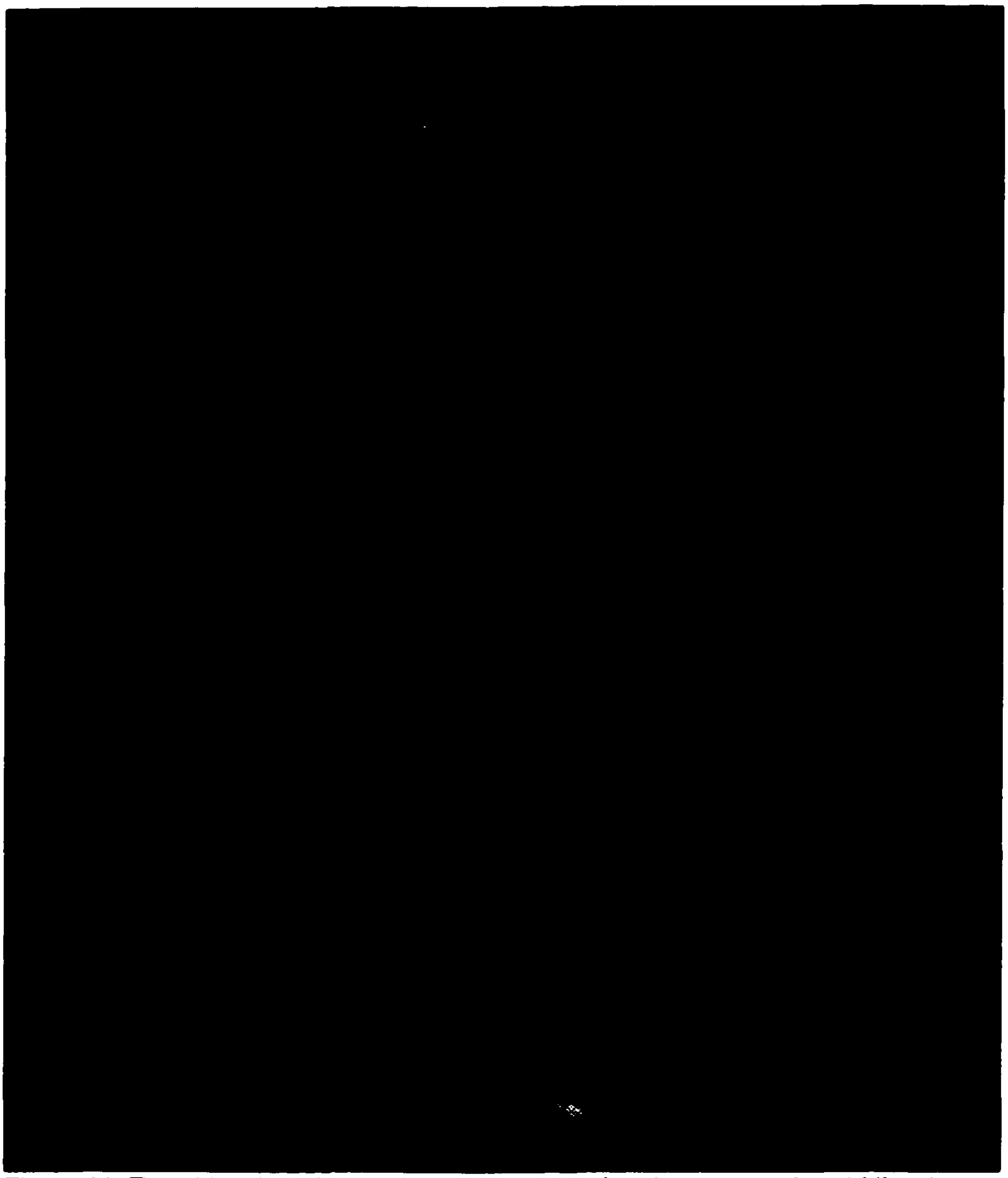

Figure 11. Transitional lumbosacral vertebra attached to the sacrum of a middle adult female (AMNH #346001) from Golovin Bay, Alaska.

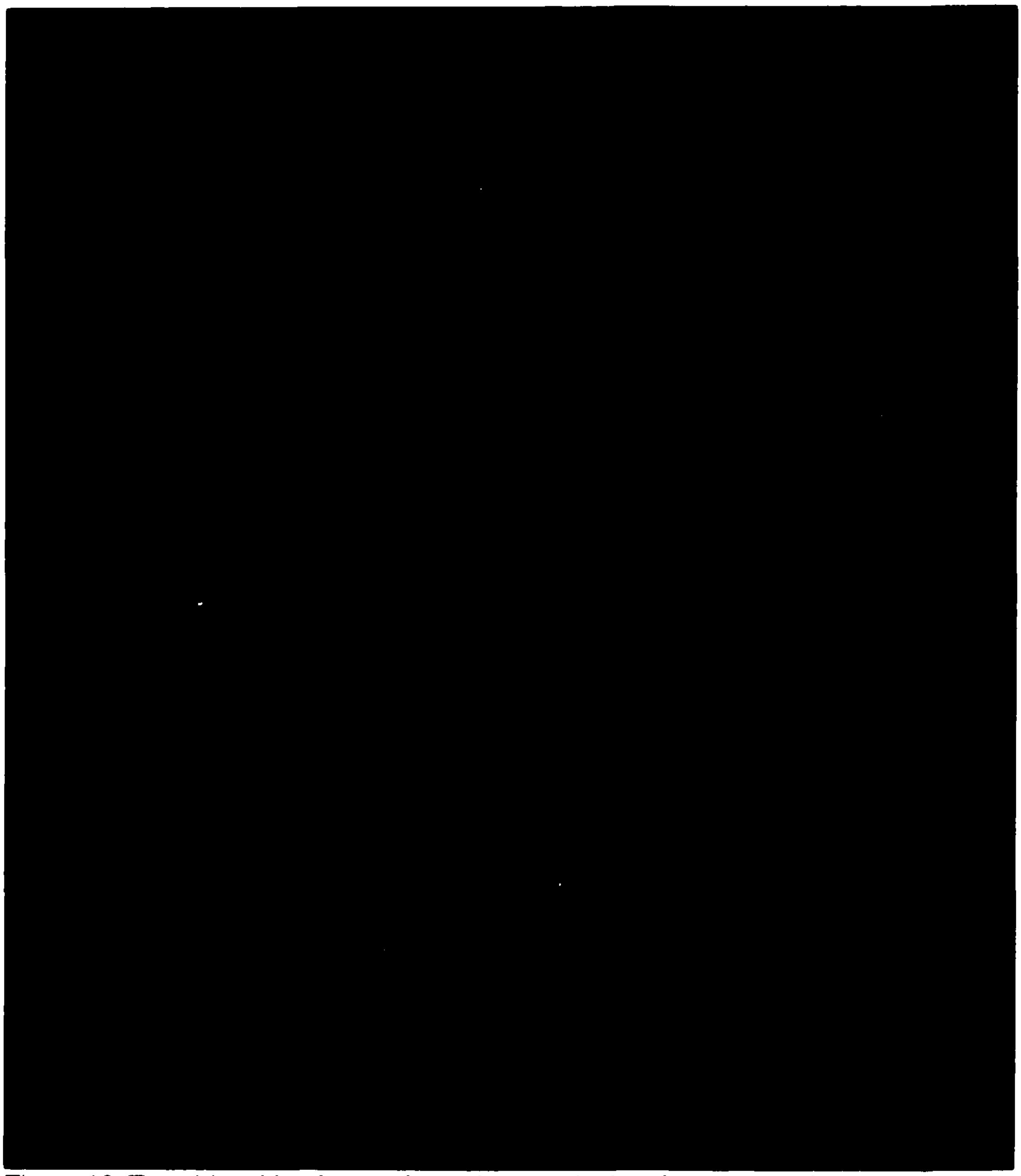

Figure 12. Transitional lumbosacral vertebra attached to the sacrum exhibiting incomplete closure of the neural arch. The sacrum is from a middle adult female (AMNH #339147) from Nunivak Island, Alaska.

summary statistics. The frequency of this condition at Nunivak is calculated at 7.7% (n = 13) (Table 24). Statistical analysis indicates that the difference in frequency between Golovin and Nunivak is not significant ($P > 0.05$), although the sample sizes are small.

Presacral fused vertebrae: Golovin Bay

Six Golovin individuals, two males and four females, exhibit fused vertebrae outside of the sacral region (Table 25). The males are identified as a late adolescent and a young adult, while three middle adults and one old adult represent the females.

Table 25. Summary of fused vertebrae at Golovin.

AMNH#	Sex	Age	Vertebrae involved
346033	Male	15 – 19	C3 & C4
346117A	Male	20 – 34	All thoracic, some cervical and lumbar
352379A	Female	35 – 49	C2 & C3
346004	Female	35 – 49	T12 & L1
352382	Female	35 – 49	C3 & C4
346028	Female	50 +	T11 & T12

Presacral fused vertebrae: Nunivak Island

There are only two individuals in the Nunivak collection with fused vertebrae. The first is a young adult female (AMNH# 329228) with complete fusion of the vertebral bodies and arches of the second and third cervical vertebrae. The second is a late adolescent (15 – 19 years), classified as a probable female (AMNH# 339235), with fused arches of the second and third cervical vertebrae.

Fractures and wedging: Golovin Bay

Non-compression fractures in the vertebral column appear in four individuals in the Golovin collection. The first is a middle adult male (AMNH# 333454) with a healed fracture of the spinous process on the fifth thoracic vertebra. Second is a middle adult female (AMNH# 352401) with a healed fracture of the spinous process of the fifth lumbar vertebra. The last two fractures are observed in sacra, one of a young adult female (AMNH# 352387) with a fracture of the left ala; the other is a middle adult female (AMNH# 352377) with a fracture through the ventral surface of the body of the fourth sacral element. Both of the fractures to the sacra show partial healing.

Wedging from compression fractures is much more common than are non-compression fractures in the Golovin collection. Wedged vertebrae are observed on at least one vertebra in 14 individuals ranging in age from adolescent (10 – 14 years) to old adult (50 + years). Vertebrae involved include the mid-thoracic through the upper lumbar regions (Table 26). Frequencies of compression fractures for observable vertebral elements in the thoracic and lumbar vertebrae (T1 - L5) are 2.2% (n = 272) for males and 3.9% (n = 436) for females. Although females are noted with a slightly greater frequency, there is no significant difference between the sexes.

Table 26. Summary of vertebral wedging at Golovin Bay.

AMNH#	Sex	Age	Vertebra(e) involved
346012	Male	35 – 49	T6
346018	Male	35 – 49	L1 & L2
352374	Male	35 – 49	T12
352394	Male	35 – 49	T8 & T12
346010	Female	20 – 34	T11 & T12
352396	Female	20 – 34	T11
346004	Female	35 – 49	T12 & L1
352377	Female	35 – 49	L1
352380	Female	35 – 49	Unknown T & two unknown L
352384	Female	35 – 49	T8, T12 & L1
346028	Female	50 +	T6, T9, T10, T11 & T12
346029	Female	50 +	L1
352403	Female	50 +	T12 & L1
346109	Subadult	10 – 14	T7

Fractures and wedging: Nunivak Island

There is only one case of a fractured vertebra in the Nunivak collection. A young adult male (AMNH# 339233A) is observed with a fracture through the right portion of the body and arch of L5. Another individual, classified as a late adolescent of indeterminate sex (AMNH# 339163), shows a partial cleft in the dorsal aspects of C2 and C3. There is no trauma associated with this defect and a congenital origin is suspected.

Only six individuals in the Nunivak collection exhibit wedging on one or more vertebrae (Table 27). Except for one individual, wedged vertebrae in this population are limited to the lower thoracic and the lumbar vertebrae; apparently no subadults were affected. The frequencies of occurrence for all observable thoracic and lumbar vertebrae (T1 – L5) are 2.5% (n = 200) for males and 1.0% (n = 200) for females.

Table 27. Summary of vertebral wedging at Nunivak Island.

AMNH#	Sex	Age	Vertebra(e) involved
339231	Male	20 – 34	T11, T12 & L1
339260	Male	35 – 49	L1
339256	Male	35 – 49	C5, C6, C7 & T12
339140	Female	35 – 49	L5
339147	Female	35 – 49	L3
339207A	Unknown	Adult	L4 & L5

DISCUSSION

Vertebral pathologies and anomalies in the Golovin Bay skeletal collection are similar in occurrence to those reported for Alaskan Eskimo populations (Gunness-Hey, 1982; Kettelkamp and Wright, 1971; Lester and Shapiro, 1968; Stewart, 1931; Stewart, 1932; Stewart, 1953). The Nunivak Island collection, however, seems to exhibit comparatively fewer vertebral pathologies. It also has a distinctively different pattern, with regard to frequencies based on sex, of several of the pathologies examined. The general subsistence bases of the regions from which the collections arise were probably similar in many respects. Both populations likely exploited a combination of land and sea resources; however, the Nunivak Island group would most likely have had a higher contribution from sea resources than the Golovin group, who had greater access to freshwater fish in their area (Koutsky, 1981; Ray, 1975). The inhabitants of the Golovin Bay region were also dependent on the caribou herds that migrated out onto the Seward Peninsula (Koutsky, 1981), whereas caribou, while no less important to the earlier people of Nunivak Island, were most likely easier to obtain on the island (Pratt, 2001). The combination of similarities and differences observed in the various vertebral pathologies between the two groups could be attributed to those differences in subsistence base.

Sexual division of labor is also a likely component in the differences in observed frequencies of activity related pathologies. At Nunivak, males were responsible for seal and walrus hunting, while the women took care of all butchering, including cleaning and drying of the esophagus, stomach, intestines, and bladder (Lantis, 1946). Fishing, using a seine, was a mutual activity for males and females, but the cleaning and preparation of the fish for drying was taken care of by the women (Lantis, 1946).

Spondylolysis

In 1931 T.D. Stewart published the first overview of the incidence of separate neural arches in Eskimo populations. He found frequencies of 57.9% for males and 40.0% for a sample from Golofnin (Golovin) Bay; he observed no cases of spondylolysis in the Nunivak Island sample. These values are not significantly different than those observed in this study. The differences in observed frequencies between the two studies may be attributable to the method applied or to changes in accessioning of the skeletal materials between their collection and subsequent repatriation 75 years later.

There is a significant difference in the frequencies of spondylolysis between the Golovin and Nunivak collections. The frequency of this anomaly at Golovin, based on individuals with complete lumbar regions only, is 54.5% (n = 33), whereas the overall frequency for Nunivak is only 5.0% (n = 20). Spondylolysis frequencies similar to that observed at Golovin are seen in the Eskimos of Greenland (Simper, 1986) and other Northern Alaskan Eskimo groups (Lester and Shapiro, 1968; Stewart, 1931), while Nunivak resembles modern Japanese (Hasebe in Stewart, 1931) and American whites and blacks (Willis, 1931) (Table 28).

Table 28. Frequencies of spondylolysis for Golovin Bay, Nunivak Island, and 13 other populations.

Population	Male %	Female %	Overall %	Source
Golovin Bay	66.7	47.6	54.5	Current Study
Nunivak Island	11.1	0.0	5.0	Current Study
Ipiutak[a]	30.4	15.0	23.3	Lester & Shapiro (1968)
Tigara[a]	48.4	51.8	49.8	Lester & Shapiro (1968)
Point Hope	41.4	50.0	44.9	Stewart (1931)
St. Lawrence Island	25.0	28.6	26.9	Stewart (1931)
Lower Yukon	9.1	13.6	11.4	Stewart (1931)
Lower Kuskokwim	23.8	13.8	19.7	Stewart (1931)
Koniag[b]	36.1	25.8	31.2	Gunness-Hey (1982)
Sadlermiut[c]	33.0	13.3	22.6	Merbs (1983)
Greenland Eskimos	61.2	48.0	54.3	Simper (1986)
Japanese	7.1	7.3	7.2	Hasebe (1912-13) in Stewart (1931)
American Whites	6.6	3.6	6.2	Willis (1931)
American Blacks	3.5	0.9	3.0	Willis (1931)
Living N. Eskimos[d]	31.9	22.6	28.1	Kettelkamp & Wright (1971)

[a] Only individuals of known sex included; [b] Data for adults 20+ years only; [c] One 15 year old female not included; [d] Includes subadults.

It has been suggested that spondylolysis frequencies are higher in northern Alaskan Eskimos, defined by Stewart (1931, 1953) as residing north of the Yukon River (see Table 28). The data presented here follow this trend, with a significantly higher rate associated with the population from Golovin Bay. Exactly what the high frequency of spondylolysis among many northern Eskimo populations reflects is not completely clear. Stewart (1953) concluded that the higher incidence in Eskimos was due to postural stresses combined with a high accident rate, and at least a small amount of anomalous ossification. When speaking of postural stress he was referring to the way in which Eskimo women bend at the waist, remaining straight legged, when reaching for something near ground level, such as berries. For men, he saw long periods of sitting in a kayak straight legged as the major contributor to this condition. One problem with this explanation is that sitting in a kayak, while stretching the tendons and ligaments of the lower back, does not provide the same stresses as an upright posture, which has been strongly linked to spondylolysis in biomechanical studies (Cyron and Hutton, 1978; Cyron et al., 1976; Rosenberg et al., 1981). Additionally, the question still remains regarding why there are differences in frequency between northern and southern Eskimo groups that both utilized kayaks.

Spondylolysis of the fifth lumbar vertebra has been associated with the weight bearing responsibilities of that portion of the lower back (Cyron and Hutton, 1978; Cyron et al., 1976). While it is not possible to assign specific activities to the pathological conditions observed here, it is possible that the northern Eskimos were walking long distances carrying heavy packs on their backs, such as when traveling to seasonal hunting grounds, or pulling heavy objects utilizing a harness (Figure 13). Ethnographic data (Koutsky, 1981; Lantis, 1946; Ray, 1964) from the two regions suggest that the Golovin Bay population likely traveled overland for seasonal subsistence to a much greater degree than did the Nunivak Islanders. The Nunivakers also traveled for seasonal hunting, but to a lesser extent (Lantis, 1946). Merbs (1983) also reported that among the Sadlermiut, the men frequently moved heavy items, such as animal carcasses or building materials, while bending at the waist without bending at the knees; this position places additional stress on the lower back. This possible cause is supported by the findings of Ichikawa et al. (1982) that axial stresses cause higher frequencies of spondylolysis in athletes than either rotational or bending stresses. They found the highest frequencies of spondylolysis among weight lifters (42.3%, n = 52) (Ichikawa et al., 1982).

Trauma cannot be completely ruled out as a causal agent in spondylolysis. Saraste (1985) found that trauma contributed to spondylolysis most often in the fourth lumbar vertebra. She performed a clinical radiographic study of 159 patients diagnosed with spondylolysis and found 135 with lysis of L5 and 24 with separation in the L4. Trauma was associated with 54% of the cases of L4 spondylolysis, while only 22% of L5 lesions were trauma related (Saraste, 1985). A recent case of bilateral spondylolysis clearly associated with acute trauma to the lower back has been reported by Cope (1988). This particular case was caused by a fall of 12 feet with the individual landing on his back. Cope claims that spondylolysis associated with acute trauma is extremely rare. He also feels that it is important to distinguish spondylolysis caused by acute trauma from that caused by activity related fatigue. It is unclear how many cases of spondylolysis in Eskimo populations are related to acute trauma rather than fatigue fractures. Simper (1986) claims that a high frequency of compression fractures in the Greenland Eskimos reflects a high incidence of trauma.

Figure 13. Bering Strait Eskimos using harnesses to pull a sled loaded with building supplies. Photo courtesy of the S.J. Call Photograph Collection, Alaska and Polar Regions Department, University of Alaska Fairbanks.

In the Golovin collection there are only four cases of fractures to the vertebrae or sacrum. Spondylolysis is noted in two of the four individuals with fractures. One individual (AMNH# 352377), with a fracture through the body of the fourth sacral element, exhibits spondylolysis of L4. The other individual (AMNH# 352401), with a healed fracture to the spinous process of L5, also has spondylolysis of L4. The two individuals with fractures who did not exhibit spondylolysis include a male (AMNH# 333454) with a healed fracture to T5 and a female (AMNH# 352387) with a partially healed fracture to the left ala of the sacrum. Both individuals showing fractures and spondylolysis exhibit the condition on L4, and both wounds are along the midline of the lower back. The two individuals with trauma and no spondylolysis include an injury to the upper back and one off the centerline of the vertebral column to the side of the sacrum.

It has been suggested that males exhibit a higher frequency of spondylolysis than females (Merbs, 1983). There was not a statistically significant difference in the occurrence based on sex for any of the comparative data, with the exception of the Sadlermiut of Canada analyzed by Merbs (1983, 1995, 1996); in this case, males exhibited a significantly higher frequency of spondylolysis than females ($P < 0.05$) (Table 28). While there appears to be a difference in the frequency of spondylolysis between males and females at Golovin, it is not statistically significant (Table 7). The highest frequencies in both sexes are observed in L5. The high frequency of L5 spondylolysis appears to be the norm for all populations in which spondylolysis has been observed (Boas, 1892; Fredrickson et al., 1984; Gunness-Hey, 1981; Krenz and

Troup, 1973; Lester and Shapiro, 1968; Saraste, 1985; Stewart, 1931), with the exception of the Greenlandic Eskimos (Simper,1986) who exhibited an equal distribution of spondylolysis between L4 and L5. The main difference between males and females is in the occurrence of spondylolysis on either the L4 or L5. In the Golovin collection females exhibit a higher frequency of L4 spondylolysis than do males, but the opposite is true for L5. This patterning indicates differential stresses on the lower back vertebrae between males and females, a condition most likely related to the sexual division of subsistence activities. As stated above, Merbs (1983) notes that males among the Sadlermiut lift heavy objects while keeping their legs straight, thus placing a great deal of strain on the low back. A similar situation may have taken place among the people of Golovin Bay.

The major finding from my study, at least with regard to spondylolysis, is the significant difference between the northern and southern Eskimo populations. However, this result, in and of itself, does not help to elucidate the etiology of the condition. Although a genetic relationship is assumed for each of the areas studied based upon language usage, there is no support for a genetic component to spondylolysis given the frequencies observed in this study. While the sample for subadults is small in both of the collections observed (see Tables B3 and C3), there are no examples of spondylolysis in subadults from either group, and therefore, no support for the argument of an anomalous ossification as a causal factor. There is also little evidence of a relationship between spondylolysis and acute trauma, as evidenced by healed or partially healed fractures, in either skeletal sample.

Spina bifida occulta

The observed frequencies of *spina bifida occulta* are not significantly different between Golovin Bay (10.9%, n = 46) and Nunivak Island (16.7%, n = 18). There is no evidence for sex-related differences in the frequency of *spina bifida occulta* in either the Golovin Bay or Nunivak Island collections. Frequencies for males (21.1%, n = 15) and females (6.3%, n = 15) at Nunivak, while apparently different, are not statistically significantly so. There is little comparative data for frequencies of this condition in skeletal samples. One comparative study by Merbs and Wilson (1960) shows a distinct sex difference in the occurrence of *spina bifida occulta* among the Sadlermiut of Canada. In their population, males exhibit the condition in 25% (n = 28) of the cases, whereas females are only affected 3% (n = 33) of the time. The overall frequency of *spina bifida* among the Sadlermiut when males and females are combined is 12.6% (Merbs and Wilson, 1960).

The frequencies of *spina bifida occulta* observed at Golovin Bay and Nunivak Island are also not significantly different from those reported for modern (15.7%, n = 140) and historic (15.2%, n = 112) skeletal samples from London (Saluja, 1988). However, in a random sample of 2707 adults in Scotland, the overall frequency of *spina bifida occulta* was 23.0% (Fidas et al., 1987). Fidas et al. (1987) state that the different frequencies obtained by various researchers most likely reflects a lack of consensus regarding the exact definition of *spina bifida occulta*. Therefore, comparisons between studies are difficult due to the lack of recording consistency. It is hoped that in the future a standardized recording and reporting strategy may be adopted in order to allow for better comparisons to be made among collections.

Spina bifida occulta is believed by some to be a developmental disorder with a strong genetic link (Carter, 1969; Laurence, 1967; Ortner and Putschar, 1985; Thomas, 1981). There are no indications of differences between the two populations studied for the occurrence of *spina bifida occulta*. Other researchers suggest that *spina bifida occulta* and spondylolysis may be related (Fredrickson et al., 1984), although the data presented here do not support this idea. Additionally, the significant difference in the occurrence of spondylolysis between the two groups and the lack of such a difference in *spina bifida occulta* would suggest the two conditions are genetically unrelated.

The clinical importance of *spina bifida occulta* is debatable (Boone et al., 1985). From the dry bone observed in this study, it is not possible to ascertain the soft tissue involvement or the effect, if any, that such an anomaly would have had on these individuals. Some researchers claim *spina bifida occulta* is very common, affecting up to 20% of the general population, with little or no clinical significance (Boone et al., 1985). If this is the case, then individuals with *spina bifida occulta* may not have exhibited any symptoms associated with the condition.

The similarities in the frequencies of *spina bifida occulta* observed among the Golovin Bay and Nunivak Island collections do not necessarily preclude the possibility of genetic differentiation between the groups. However, these findings support the idea that there may be some genetic relationship between these two populations, at least with regard to pathologies of the lower spine.

Schmorl's nodes

Differences observed in the frequencies of Schmorl's nodes between males and females in the Golovin collection point to different repetitive activities than those performed at Nunivak. Males from Golovin show a significantly higher frequency of lesions in the thoracic vertebrae than females; among females the lumbar vertebrae are more affected. Males from Nunivak exhibit greater frequencies of lesions in the thoracic and lumbar regions than females.

When comparing the Golovin Bay and Nunivak Island collections, differences are observed in the frequencies of Schmorl's nodes in both the thoracic and lumbar segments of the males. No significant differences are seen between the vertebral segments of females. While a lack of a difference in the females does not implicate activity differences, the higher frequencies of lesions among the males of Nunivak does suggest repetitive stresses different from those performed at Golovin. A greater amount of heavy lifting among the males at Nunivak could account for the higher frequency of intervertebral disc herniations in that sample. Schmorl's nodes are activity related lesions, rather than having a strictly genetic etiology; as such, they may be better indicators of differences in vertebral related stresses than those lesions with stronger genetic ties. Good comparative data for Schmorl's nodes are not available, but in future work on spinal pathologies, a thorough examination of intervertebral disc herniations should be included with any other examination of stress related pathologies.

Osteoarthritis/Degenerative Joint Disease

Included in this category are observations of osteophyte development, porosities of the joint surfaces, and general remodeling associated with intervertebral disc degeneration. These are by far the most common of vertebral pathologies in both skeletal collections. A significant increase in the frequency of spinal degeneration coincident with increased age is noted for both Golovin Bay and Nunivak Island. Males at Golovin exhibit higher frequencies than females in all vertebral segments examined; however, the only values that are significantly different between males and females are those of the thoracic vertebrae. At Nunivak a distinctly different pattern is observed. Whereas males exhibit a significantly greater frequency of cervical degeneration, females show a greater frequency of lumbar degeneration. There is no difference in degeneration of the thoracic region between Nunivak males and females. Merbs (1983) notes that females among the Sadlermiut carried children on their back, placing stresses on the low to mid-thoracic region. He also states that pregnant women would have had similar stresses on the lower thoracic vertebrae (Merbs, 1983). Using these arguments, one would expect females to exhibit a higher frequency of thoracic lesions than males. However, this was not the case in either of the skeletal samples examined. Among the people of Nunivak, Lantis (1946) observed that males often carried driftwood using a wooden breast yoke and pack. A pack of this type would have created similar stresses to that of carrying a child on one's back.

Stewart (1947) examined osteophytic remodeling among Eskimos, Pueblo Indians, and American whites. He found osteophytic lipping most commonly occurred in the lumbar vertebrae of the Eskimos he studied. This finding differed from that observed in the Pueblo Indians, where lipping generally occurred in all regions of the spine, and in American whites, where the greatest amount of lipping was in the cervical region (Stewart, 1947). Among the two populations analyzed here, only females from Nunivak show a significantly greater amount of remodeling in the lumbar region. Both males and females from Golovin exhibit general remodeling that is nearly equal throughout the vertebral column. There is a large amount of individual variation in the severity of osteophytic and/or arthritic remodeling in each population.

Marked differences in the frequency of vertebral degeneration between Golovin Bay and Nunivak Island are noted for both males and females. The patterning of the pathology, as well as the frequencies observed, lend support to the idea that differential repetitive stresses were causing very different problems in the backs of individuals in each population. As with Schmorl's nodes, greater differences were observed in osteoarthritis frequencies between the males of the two collections than the females. In general, both a greater frequency of degeneration and a larger degree of remodeling marked the vertebral columns of individuals from Golovin compared with those from Nunivak.

Transitional lumbosacral vertebrae

Transitional lumbosacral vertebrae are most evident in the Golovin collection, although this may simply be an artifact of the smaller sample size from Nunivak. Unfortunately statistical analysis of this condition is difficult because of the nature of the recording of the trait. The most common form of transitional lumbosacral element observed in the Golovin collection involves cases in which the first sacral element is either incompletely fused to the second element, or has ala resembling the transverse processes of a lumbar vertebra. This condition is observed in 12 of the 14 individuals included in the analysis. The remaining two individuals exhibit last lumbar vertebrae with transverse processes resembling the ala of the sacrum. In most instances, it appears that the vertebra involved is the first sacral element. However, because of the incomplete nature of the vertebral columns in general, it is not always possible to make an absolute determination.

The two transitional lumbosacral vertebrae observed in Nunivak are both observed in young adults, including one male and one female. The male (AMNH# 339133) includes a complete lumbar segment and sacrum. A sixth lumbar vertebra in this individual has taken on characteristics of the sacrum. The sacrum of the female (AMNH# 339147) includes six elements, with an only partially fused first vertebra.

The etiology of transitional lumbosacral vertebrae is believed to be genetic (Bennett, 1972; Lanier, 1954), and there is no significant difference observed in the occurrence of this condition between the two samples studied. It has been suggested that there is a relationship between *spina bifida occulta* and transitional lumbosacral vertebrae (Bennett, 1972). However, a G-test for independence of *spina bifida occulta* from transitional lumbosacral vertebrae was performed for each collection and no significant dependence was noted.

Fused vertebrae

Of the six cases of vertebral fusion observed at Golovin, two individuals exhibit block vertebrae that are clearly congenital. A middle adult female (AMNH# 352379A) shows fusion of the second and third cervical vertebrae (Figure 14). The vertebrae are attached at the inferior articulations of C2 and the superior articulations of C3, and between the laminae of the neural arches. Osteoarthritis is observed on the odontoid process of C2 and the inferior articular surfaces of C3, but it is not severe and is more likely a result of the block vertebrae rather than the cause. Similarly, a late adolescent classified as a probable male (AMNH# 346033) has third and fourth cervical vertebrae that are connected at the left lamina and partially connected on the right side as well (Figure 15). The vertebral pathologies exhibited in both individuals are most likely related to Klippel-Feil syndrome, characterized by any type of segmentation failure in the developing cervical spine (Spillane et al., 1957). Genetically, Klippel-Feil syndrome is believed to be an autosomal dominant trait (Barnes, 1994), although there is still a great deal of debate on this topic as well (McKusick, 1992).

The frequency of occurrence of block vertebrae of this type in other populations varies greatly, although very few comparative samples are available. For instance, among a small series of skeletons from northeastern Arizona, attributed to the prehistoric Kayenta Anasazi, five males were observed exhibiting congenital fusion of C2 and C3 (Wade, 1981). The overall frequency in their sample is 17.2%, although all cases of C2/C3 fusion were males. The predominance of males affected differs from the findings of a number of other researchers who observed a much higher frequency

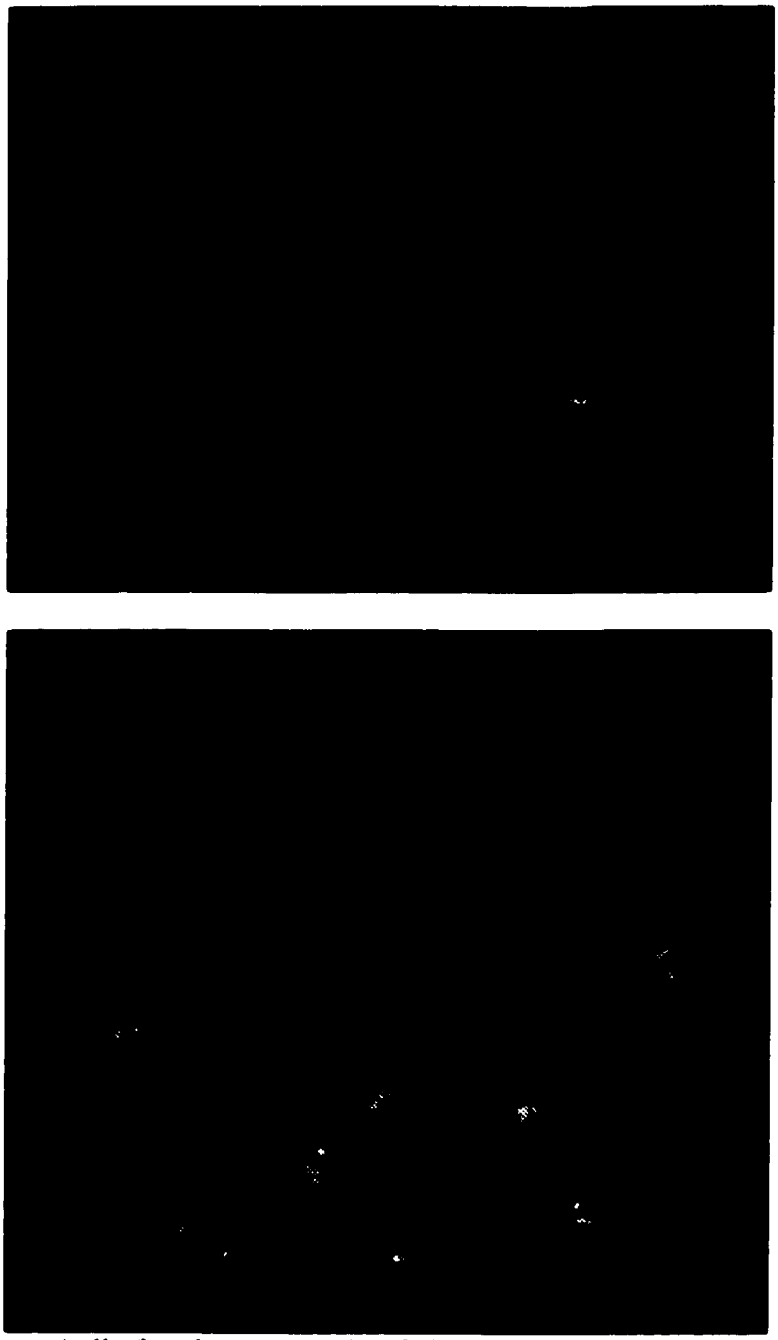

Figure 14. Congenitally fused (segmentation failure) second and third cervical vertebrae from a middle adult female (AMNH #352379A) from Golovin Bay, Alaska. Anterior (top). Right lateral (bottom).

Figure 15. Congenitally fused (segmentation failure) third and fourth cervical vertebrae of a late adolescent male (AMNH #346033) from Golovin Bay, Alaska.

among European females (Gilmour, 1941; Gorlin and Pindborg, 1964). There was no apparent sex difference observed in the Golovin sample, with one male and one female each affected.

One other individual from Golovin exhibited fusion in the cervical region only. This middle adult female (AMNH# 352382) had fusion between the third and fourth cervical vertebrae that has subsequently been broken post-depositionally. There is extreme osteophyte development and osteoarthritis remodeling throughout the vertebral column of this individual. This fusion is clearly the result of advanced osteophytic development in the cervical vertebrae rather than a congenital condition.

Severe osteophyte development and osteoarthritis throughout the vertebral column are associated with lower back vertebral fusion in two other individuals. The first is a middle adult female (AMNH# 352379A) with fusion of the twelfth thoracic and first lumbar vertebrae. The second is an old adult female (AMNH# 346026) who appears to have had fusion of the eleventh and twelfth thoracic vertebrae that has become separated post-mortem (Figure 16). Both of these individuals show extensive osteoarthritic remodeling throughout the column, as well as numerous Schmorl's nodes suggesting severe repetitive stresses, such as lifting heavy objects, during their lifetimes.

Finally, a young adult male (AMNH# 346117A) at Golovin exhibits fusion of all of the thoracic vertebrae, as well as some of the cervical and lumbar vertebrae. Fusion has also taken place between most of the ribs and the thoracic vertebrae (Figure 17). Diagnosis of the particular pathology is slightly problematic. Ortner and Putschar (1985) examined this same individual and came to the conclusion that it is most likely a case of rheumatoid arthritis, although ankylosing spondylitis can not be completely ruled out. My analysis of this individual is in agreement with their findings. Involvement of most of the vertebral elements, degeneration of other joints, including severe osteoarthritis in both knees and some new bone development in the elbow, coupled with the lack of fusion of the sacroiliac joint all point to a diagnosis of rheumatoid arthritis.

Rheumatoid arthritis is a relatively rare disease that affects approximately 2% of modern populations (Aufderheide and Rodríguez-Martín, 1998) and is usually seen in greater frequencies among females (Rothschild et al., 1990). The exact etiology of the condition is not known, but it is believed to be an autoimmune response of some kind (Aufderheide and Rodríguez-Martín, 1998).

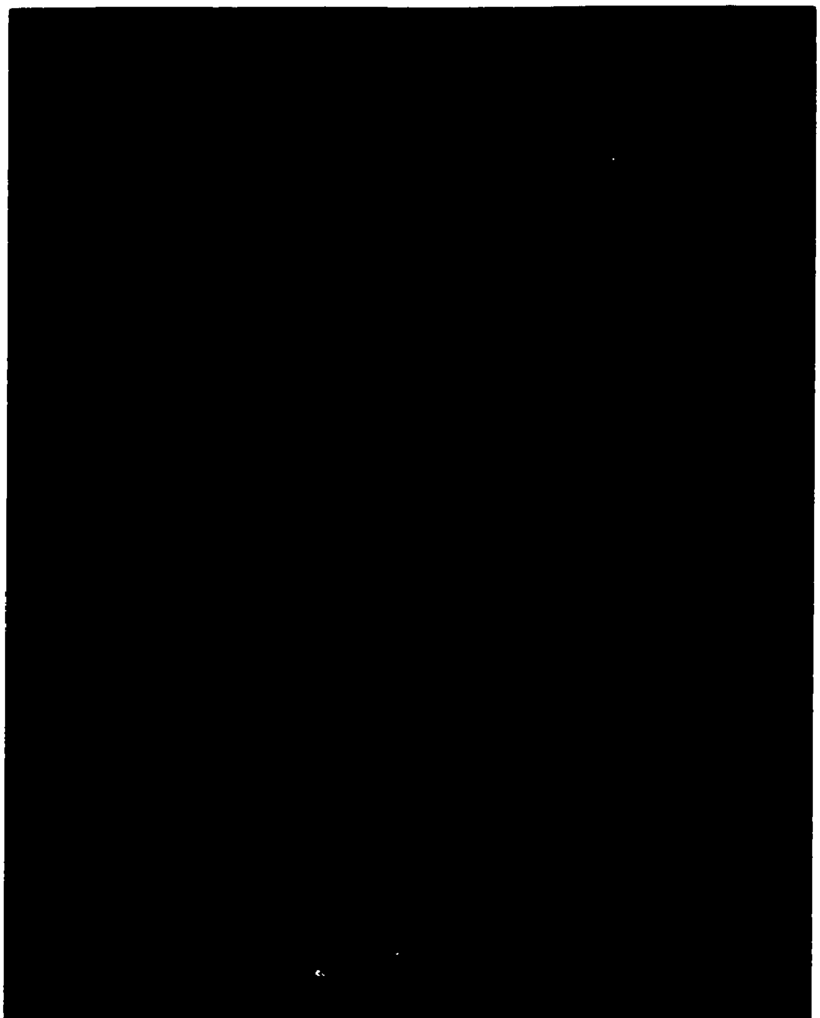

Figure 16. Fused eleventh and twelfth thoracic vertebrae with severe osteophytic remodeling from an old adult female (AMNH #346028) from Golovin Bay, Alaska.

Figure 17. Ribs fused to the thoracic vertebrae in a young adult male (AMNH #346117A) with rheumatoid arthritis from Golovin Bay, Alaska.

Only two individuals in the Nunivak collection exhibit fused vertebrae of any kind. A young adult female (AMNH# 339228) and an adolescent child (AMNH# 352401) each show segmentation failure of the second and third cervical vertebrae (Figures 18 & 19). In each case, the neural arches are attached; in the case of the young

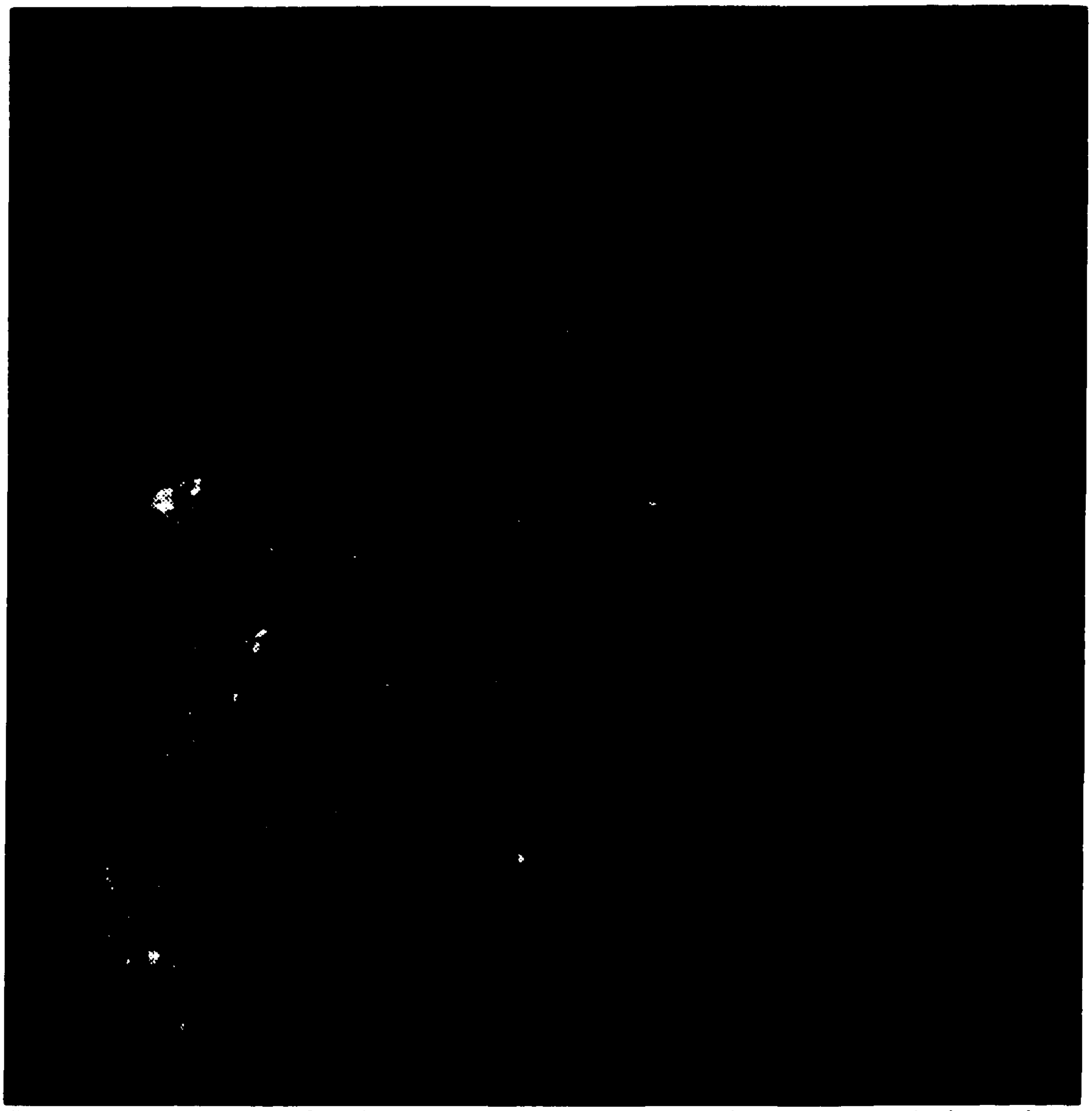

Figure 18. Congenitally fused (segmentation failure) second and third cervical vertebrae of a young adult female (AMNH #339228) from Nunivak Island, Alaska.

Figure 19. Congenitally fused (segmentation failure) second and third cervical vertebrae of an adolescent child (AMNH #339235) from Nunivak Island, Alaska.

adult female, the vertebral bodies are also connected. Both cases are believed to represent examples of Klippel-Feil syndrome. There is no indication of osteophytosis in either individual. Moderate arthritis, in the form of porosities on the superior articular facets of C4, is present in the child, most likely a result of the fusion. Unlike Golovin, no males are affected at Nunivak; however, this condition is very rare, making characterization of the trait in either collection difficult.

Fractures and wedging

Healed or partially healed fractures to the vertebral column are observed in four individuals from Golovin. Two middle adults including one male (AMNH# 333454) and one female (AMNH# 352401) each show a healed fracture of an individual vertebra. The fifth thoracic vertebra of the male has a healed fracture of the spinous process resulting in a noticeable misalignment of that process from the rest of the column. No other trauma is noted for this individual. The female exhibits a healed fracture to the spinous process of the fifth lumbar vertebra resulting in a broad flat appearance. This individual is also noted as having a fracture of the left clavicle that has formed a pseudarthrosis at mid-shaft. It is not clear from the skeleton if the two injuries are related.

The two other individuals with trauma both exhibited fractures to the sacrum. The first is a young adult female (AMNH# 352387) with a partial fracture through the left ala. Woven bone is apparent, but there is incomplete union of the break. No other trauma is noted in this individual. Second is a middle adult female (AMNH# 352377), with a fracture through the ventral surface of the body of the fourth sacral element with a small amount of new bone formation in the area, and a partially healed fracture on the costal end of a mid-thoracic rib. This individual also exhibits wedging of L1, and a Schmorl's node and spondylolysis on L4. From the remains it is unclear if there is a relationship between the rib fracture and the trauma noted in the lower back; however, there is most likely a cause and effect relationship with the lower back trauma and the other pathologies noted. The exact nature of that interaction is unclear, but any trauma to the sacrum could also have resulted in the vertebral compression fracture noted.

Vertebral compression fractures, in the form of wedging, are noted in 14 individuals from Golovin (Table 26, Figure 20). In all adult cases, osteophyte development, osteoarthritis, or trauma in other areas of the skeleton are also noted. Eight of the 14 show wedging on more than one vertebra. Females are affected more often than are males; 3.9% (n = 436) of the total female vertebrae observed between T1 and L5 show wedging, whereas wedging occurs in males 2.2% (n = 272) of the time. This difference, however, is not significant. There is also no significant difference in the frequency of occurrence in the thoracic or lumbar vertebrae between the sexes.

A single individual from Golovin Bay, classified as an adolescent of indeterminate sex (AMNH# 346109), exhibits an occurrence of what appears to be a sagitally cleft body of T7 (Figure 21), a possible result of a failure of the notochord to properly recede in the developing vertebra (Barnes, 1994). The condition is normally observed in the lumbar and thoracic regions (Barnes, 1994). No other anomalies or pathologies are present in the vertebral column of this young individual.

The only case of non-compression related vertebral trauma in the Nunivak collection comes from a young adult male (AMNH# 339233A) with a fracture through the right portion of the body and arch of L5. Little evidence of new bone formation is noted. No other trauma is observed in this individual, although the L5 was the only

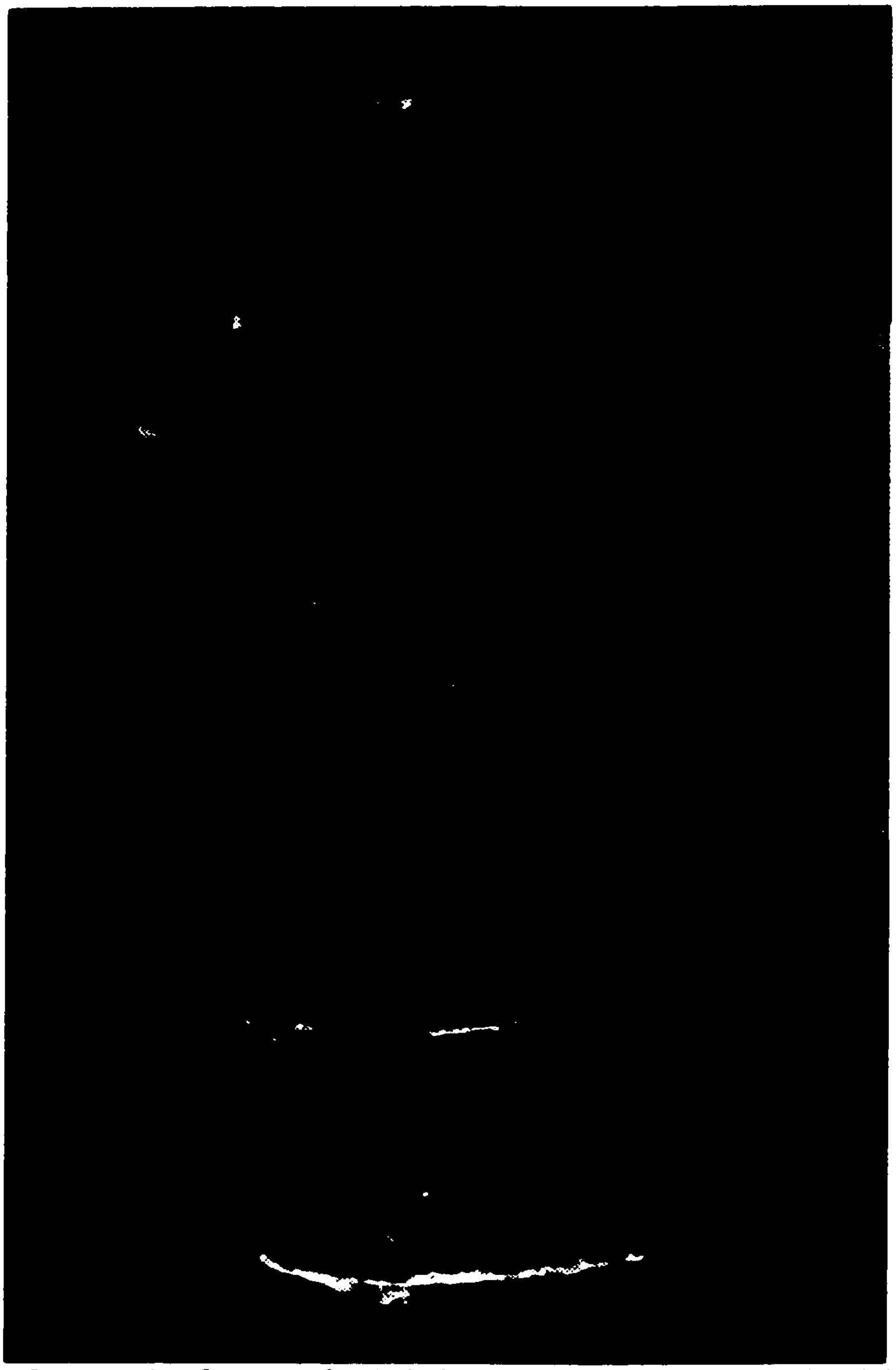

Figure 20. Compression fracture of a sixth thoracic vertebra from a middle adult male (AMNH #346012) from Golovin Bay, Alaska.

lumbar vertebra present. The limited skeletal material for this individual make any remarks regarding the nature of the trauma impossible; however, it appears that it did occur at or near the time of death, based on the very minor amount of remodeling that has taken place.

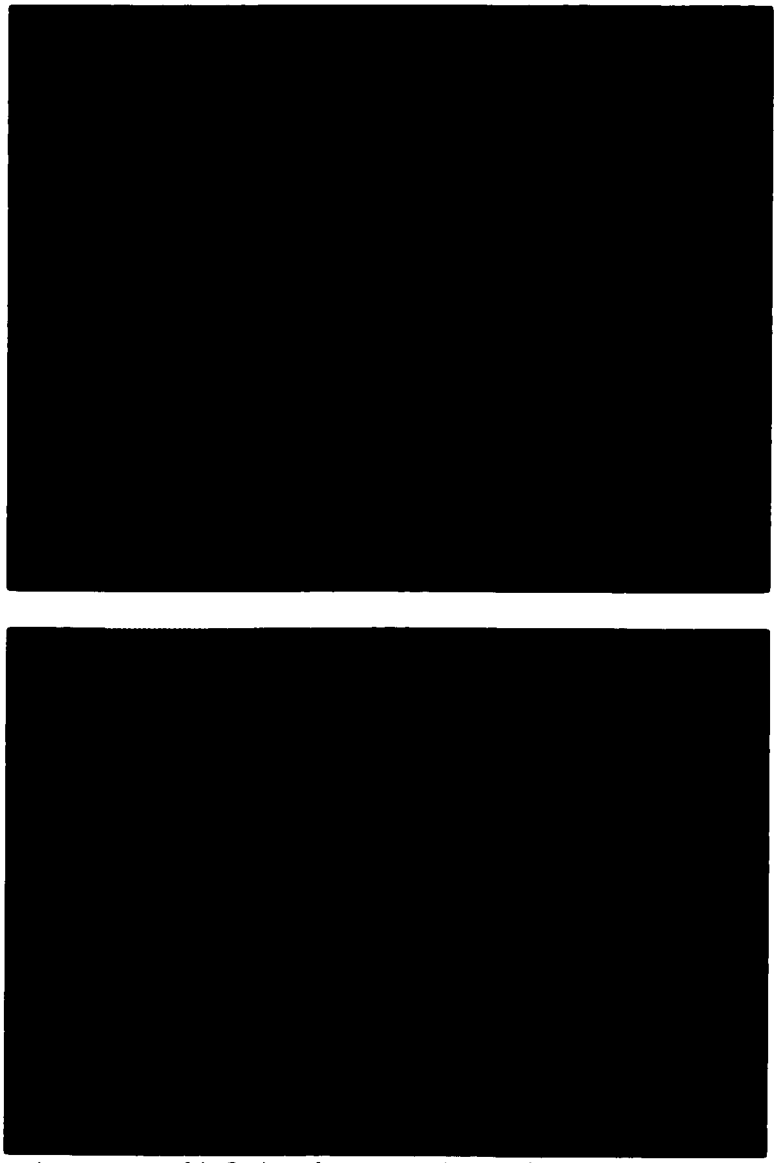

Figure 21. Superior (top) and inferior (bottom) views of sagitally cleft vertebral body of T7 from an unknown sex adolescent (AMNH #346109) from Golovin Bay, Alaska.

Compression fractures are observed in six individuals from Nunivak. Only three of the six exhibit wedging on more than one vertebra. Frequencies of wedging, when considering observable vertebrae from T1 to L5 at Nunivak, are 2.5% (n = 200) for males and 1.0% (n = 200) for females. Once again these values are not significantly different.

Only one individual in the two collections exhibited any vertebral compression in the cervical vertebrae. A middle adult male (AMNH# 339256) from Nunivak shows compression of the fifth, sixth, and seventh cervical vertebrae as well as the twelfth thoracic vertebra. This individual also exhibits extreme osteoporosis and degenerative arthritis in all vertebral elements present. It appears that osteoporosis was the major contributor to all vertebral compression in this individual. Healed traumas to the frontal, the sternal end of the right first rib, and right acromion are also noted. It is not unusual for males to exhibit osteoporosis, though females are generally more affected (Stini, 1995). However, osteoporosis in males most often occurs later in life (Stini, 1995), which makes this case of a middle adult male with such severe osteoporosis unusual.

Finally, one individual from Nunivak, classified as a late adolescent (AMNH# 339163), shows a cleft in the dorsal bodies of the second and third cervical vertebrae (Figures 22 & 23). There is no trauma associated with this condition and it is most likely a congenital disorder. The body of C2 is less affected than that of C3 and some bony bridging is noted near the superior margin of the centrum of C3. The entire vertebral column, including the unfused sacrum, is present for this individual and no other vertebral pathologies are noted. Barnes (1994) describes a similar condition of sagittal cleft centrum resulting from failure of the notochord to properly recede in the developing vertebra. She states that the condition is normally observed in the lumbar and thoracic regions. It appears that a partially cleft centrum of this type involving two cervical vertebrae is extremely rare and no similar cases are noted in the literature reviewed. Assuming a similar etiology to the sagittal cleft centrum described by Barnes (1994), the condition is most likely genetic in origin. The clinical significance of the condition for this individual is also not known, however, it may have been a contributing factor in their early death.

Figure 22. Inferior view of cleft centrums of the second and third cervical vertebrae from a late adolescent of indeterminate sex (AMNH #339163) from Nunivak Island, Alaska.

Figure 23. Superior view of cleft centrums of the second and third cervical vertebrae from a late adolescent of indeterminate sex (AMNH #339163) from Nunivak Island, Alaska.

When comparing frequencies of compression fractures at Golovin Bay and Nunivak Island, there is no significant difference in overall occurrence among adults. However, when separated by sex, females at Golovin (3.9%) exhibit a significantly higher frequency than females at Nunivak (1.0%) ($P < 0.05$). No difference is noted between males in the two populations (Golovin 3.2% and Nunivak 1.7%). Merbs (1983) states that the high frequency of compression fractures he observed in the Sadlermiut (Females 12% and males 9%, for observable vertebrae from T3 to L5) is most likely due to sledding or tobogganing over rough surfaces. He predicts that groups inhabiting similar geographic regions, but not utilizing sleds or toboggans for long distance travel, should exhibit a lower frequency of these types of traumas (Merbs, 1983).

Additionally, Merbs (1983) hypothesizes that females, who most likely rode in the sleds more often than males, would show a higher incidence of compression fractures. Higher frequencies in females were observed among the Sadlermiut as well as the skeletal collection from Golovin Bay, although the difference between males and females at Golovin was not significant. The people of Nunivak Island were not known to rely heavily on dogs for travel. They preferred to use a kayak, and rarely used dogs to pull sleds (Lantis, 1946). Populations surrounding Golovin Bay, however utilized sled dogs for a great deal of their travel and work in the region (Ray, 1975; Ray, 1983; Renner, 1979). These observations would help to explain the differences in the frequencies of compression fractures if the use of dog sleds was expected to be a primary cause of this type of injury. Nevertheless, among the pathologies related to activities and/or trauma (e.g. osteoarthritis, Schmorl's nodes), compression fractures are another indication of differences in activities among females in the two skeletal collections.

SUMMARY AND CONCLUSIONS

The now reburied skeletal remains from Golovin Bay and Nunivak Island provide us with the opportunity to examine vertebral pathologies in earlier people from two distinct geographic regions of Alaska, which exploit similar resources. The primary objective of this study has been to determine the patterns of those conditions that are believed to be either genetic or activity related in origin in skeletal collections from Golovin Bay and Nunivak Island. Vertebral anomalies and pathologies observed in this study include spondylolysis, *spina bifida occulta*, Schmorl's nodes, osteoarthritis, transitional lumbosacral vertebrae, and fractures.

It has been hypothesized that conditions with a known genetic etiology would be similar between the two groups, and those more closely tied with subsistence related activities would show marked differences. It was also expected that males and females should differentially exhibit pathologies tied to subsistence.

The hypothesis that conditions with a known genetic etiology would be similar in the two study samples was supported. Two conditions with a supposed genetic origin, *spina bifida occulta* and transitional lumbosacral vertebrae, exhibit similar frequencies between the samples studied. Recording differences for *spina bifida occulta* in other studies make comparisons difficult; however, it appears that the overall frequencies observed in the two samples here are similar to reported frequencies in other groups.

There is no evidence of any relationship between *spina bifida occulta* and spondylolysis in either group.

A further hypothesis was that activity related pathologies would show marked differences between the study samples. Distinct differences are evident between the two collections studied for skeletal conditions that are considered to be activity related pathologies: osteoarthritis and Schmorl's nodes. The patterning of Schmorl's nodes and osteoarthritis occurrence in the two samples points to differences in activities between groups. It appears that the activities of the males are the most different, based upon frequencies of occurrence of these two pathologies. Differences in activities between the males of the two collections may have included longer travel distances for subsistence resources at Golovin Bay and a greater amount of heavy lifting at Nunivak Island.

Spondylolysis, which may have a genetic basis, is observed in significantly greater frequencies in the skeletons from Golovin Bay. The occurrence of this condition at Golovin more closely resembles other northern Eskimo and Greenlandic Eskimo populations (Lester and Shapiro, 1968; Simper, 1986; Stewart, 1931). Spondylolysis is nearly non-existent in the Nunivak Island collection. The frequency of 5% (n = 20) from Nunivak more closely resembles observed frequencies in modern American black and white populations (Willis, 1931), and a Japanese population from the early 1900s (Hasebe in Stewart, 1931). Given suggestions that the etiology of spondylolysis is tied to a genetic predisposition (Fredrickson et al., 1984; Hensinger, 1989; Kettelkamp and Wright, 1971; Merbs, 1983; Ortner and Putschar, 1985; Wiltse et al., 1976), the differences observed in the occurrence of spondylolysis may be attributable to some genetic separation between the two samples studied. However, based upon the overall patterning of activity related lesions of the spine and similar differences in the occurrence of spondylolysis, it is most likely that subsistence related actions are the triggering mechanism in the observed differences when the two collections are compared.

The exact activity or activities responsible for differences in spondylolysis frequencies are not known; however, it has been noted that the people of Nunivak did not walk long distances to procure food (Lantis, 1946), whereas the inhabitants surrounding Golovin Bay would have followed seasonal caribou herds and exploited fresh-water fish resources inland from the coast (Ray, 1983). Caribou hunting was important to the people in both areas, although the caribou herd on Nunivak did not migrate (Pratt, 2001). Caribou, therefore, were available to the people of Nunivak Island on a year-round basis rather than seasonally, as was the case on the Seward Peninsula. Therefore, an activity that may have been a major contributor to the higher incidence of spondylolysis was walking long distances while carrying heavy packs, such as when following caribou herds or moving to seasonal villages.

Associated with the hypothesis that activity related pathologies would be different between the two samples, is the hypothesis that males and females would differentially exhibit those pathologies within the samples. Data in support of this hypothesis have been presented in this study. Schmorl's nodes are present in higher frequencies in the thoracic vertebrae of males and the lumbar vertebrae of females from

Golovin. Males from Golovin also exhibit higher frequencies of osteoarthritis in all vertebral segments, although the only significant difference is in the thoracic vertebrae. These results indicate that males from Golovin Bay were participating in activities that had a greater effect on the thoracic region of the spine than the females. These activities may have included paddling a kayak, carrying a heavy pack on the back and walking long distances, and lifting heavy objects. Males in the Nunivak collection exhibit higher frequencies of Schmorl's nodes in both the thoracic and lumbar vertebrae than do the females. However, a similar pattern is not reflected in the observation of osteoarthritis in this sample. Females exhibit greater osteoarthritis involvement of the lumbar vertebrae than males, yet there is no difference in the occurrence of osteoarthritis in the thoracic region.

No statistically significant differences are observed in the frequencies of spondylolysis between males and females at Golovin. However, among males the frequency of L5 spondylolysis is statistically significantly higher than the frequency of L4 spondylolysis. Whereas, among females at Golovin there is no significant difference in the frequencies of L4 and L5 spondylolysis. The differential occurrence of spondylolysis between the fourth and fifth lumbar vertebrae may reflect different activities between males and females at Golovin Bay. Similar comparisons between males and females within the Nunivak collection are not possible because of the limited occurrence of this pathology.

Other conditions observed in this study include vertebral fusion and fractures. The only difference noted in any of these was in the occurrence of compression fractures among females from the two samples. Females from Golovin exhibit a significantly higher frequency of compression fractures than females from Nunivak (3.9% vs. 1.0%). The reason for this difference is not known, but Merbs (1983) speculates that females from populations that utilized sleds or toboggans for travel would have a higher frequency of compression fractures. That may be the case here, but the difference in occurrence is relatively small compared with the high frequency of compression fractures in females observed by Merbs among the Sadlermiut (12%).

In general, vertebral health among the Golovin Bay skeletal collection can be characterized as poor when compared with that of Nunivak Island. The high prevalence of spondylolysis, coupled with osteoarthritis and intervertebral disc herniations, speaks of clinically significant back problems in both males and females, although not necessarily from the same causes. The skeletal collection from Nunivak Island shows slightly better vertebral health than that of Golovin. Individuals from Nunivak are characterized by an overall lack of spondylolysis and milder osteoarthritis than seen in the Golovin collection. It seems that the subsistence related activities of the Golovin Bay sample took a much greater toll on the back than did the activities of those from Nunivak.

Concurrent with the hypothesis testing summarized above, this study has examined the comparability of data sets collected using the Smithsonian Protocol for Skeletal Analysis prior to repatriation. As noted, the two skeletal collections utilized were reburied after analysis, making the Smithsonian Protocol data the primary source for information on these particular collections. Therefore, it is important to ask whether the data collected are useful in answering specific questions relating to activities of past populations. The analysis presented above suggests that many questions concerning activity related pathologies may be addressed. However, more detailed data need to be recorded in order to help with standardization. There are several problems with the database itself that could be easily solved. Within the protocol used, there are no easy ways to record locations of multiple Schmorl's nodes on individual vertebrae. The height of the sacral hiatus is not recorded, which may be a problem in misinterpretation of *spina bifida occulta*. There is also no way to record sagitally cleft vertebral bodies; although given the rarity of this trait that oversight is understandable. No distinction is made between degenerative joint disease and degenerative disc disease in the vertebrae. Furthermore, there is no indication of whether or not a particular trait is observable on a partial vertebra or sacrum. Finally, more space needs to be allocated for narrative description of the remains. Each of these problems could be easily remedied with small changes to the database itself.

Comparisons among skeletal collections using this type of protocol may be complicated by differences in the recording of traits by multiple observers. Although most traits were recorded in each of the collections analyzed, there was differential treatment of similar conditions (i.e. age related osteophytosis and osteophytic remodeling associated with osteoarthritis). Due to inconsistencies in the way some traits are handled, degenerative joint disease, degenerative disc disease, osteophytosis, and osteoarthritis had to be combined for analysis purposes in the present study. Nevertheless, it is possible to answer many questions about both activity related and genetically determined anomalies and pathologies using this method prior to repatriation. Such data are also useful for statistical comparisons among different collections.

In conclusion, the specific etiology of spondylolysis cannot be answered from this study, but it does support the claim of previous researchers that northern Alaskan populations exhibit a significantly higher frequency than southern Alaskans. There is also no evidence for a relationship between spondylolysis and *spina bifida occulta*. It appears that although each may have a genetic component to their etiology, the trigger mechanism behind spondylolysis is present in the northern Alaskan skeletal sample studied here. Because the material related to this study has been repatriated, further analysis of questions that have arisen is, unfortunately, not possible. However, this work does elucidate the need for a more standardized recording method for *spina bifida occulta*, Schmorl's nodes, and transitional lumbosacral vertebrae, so that more useful comparisons between skeletal samples can be made. The general frequencies of each of these individual pathologies and anomalies, in and of themselves, may not be indicative of a particular activity; yet, the patterning of all of them combined within a population may help us to better understand the nature of the activities performed by past populations and the impacts of those activities on their vertebral health.

LITERATURE CITED

ADCED (2001) Alaska Community Information Summary, Golovin: Alaska Department of Community & Economic Development, Division of Community & Business Development, Research & Analysis Section.

Allbrook DB (1955) The East African Vertebral Column. American Journal of Physical Anthropology *13*:489-513.

Anderson DM, Keith J, Novak PD, and Elliott MA (1994) Dorland's Illustrated Medical Dictionary, 28th Edition. Philadelphia: W.B. Saunders Company.

Arriaza BT, Merbs CF, and Rothschild BM (1993) Diffuse Idiopathic Skeletal Hyperostosis in Meroitic Nubians from Semna South, Sudan. American Journal of Physical Anthropology 92:243-248.

Aufderheide AC, and Rodríguez-Martín C (1998) The Cambridge Encyclopedia of Human Paleopathology. New York: Cambridge University Press.

Barnes E (1994) Developmental Defects of the Axial Skeleton in Paleopathology. Niwot: University of Colorado Press.

Bass WM (1995) Human Osteology: A Laboratory and Field Manual. Columbia, MO: Missouri Archaeological Society.

Batts MJ (1939) The etiology of spondylolisthesis. The journal of bone and joint surgery *21*:879-884.

Bennett KA (1972) Lumbo-sacral malformations and spina bifida occulta in a group of Proto-historic Modoc Indians. American Journal of Physical Anthropology *36*:435-440.

Birket-Smith K (1924) Preliminary report of the Fifth Thule Expedition: Physical anthropology, linguistics and material culture: Proceedings of the Twentyfirst International Congress of Americanists, Part Two held at Gothenburg 1924. Reprinted 1968. Nendeln: Kraus, pp. 191-205.

Boas F (1892) The Growth of Children. Science *19*:256-257, 281-282.

Boone D, Parsons D, Lachman SM, and Sherwood T (1985) Spina bifida occulta: Lesion or anomaly? Clinical Radiology *36*:159-161.

Bornstein PE, and Peterson RR (1966) Numerical Variation of the Presacral Vertebral Column in Three Population Groups in North America. American Journal of Physical Anthropology *25*:139-146.

Bridges PS (1992) Prehistoric arthritis in the Americas. Annual Review of Anthropology *21*:67-91.

Capasso L, Kennedy KAR, and Wilczak CA (1999) Atlas of Occupational Markers on Human Remains, Journal of Paleontology, Monographic Publication 3. Teramo: Edigrafital S.p.A.

Carter CO (1969) Spina bifida and anencephaly: A problem in genetic-environmental interaction. Journal of Biosocial Science *1*:71-83.

Cave AJE (1930) On Fusion of the Atlas and Axis Vertebrae. Journal of Anatomy *64*:322-343.

Chandraraj S, and Briggs CA (1991) Multiple Growth Cartilages in the Neural Arch. The Anatomical Record *230:*114-120.

Collins HBJ (1927) The Eskimo of Western Alaska: Explorations and Fieldwork, 1927, Smithsonian Institution. Washington, D.C.: Government Printing Office, pp. 149-156.

Collins HBJ (1928) Check-stamped pottery from Alaska. Journal of the Washington Academy of Sciences *18:*254-256.

Cope R (1988) Acute Traumatic Spondylolysis. Clinical Orthopaedics *230:*162-165.

Crubézy E, and Trinkaus E (1992) Shanidar 1: A case of hyperostotic disease (DISH) in the Middle Paleolithic. American Journal of Physical Anthropology *89:*411-420.

Cyron BM, and Hutton WC (1978) The Fatigue Strength of the Lumbar Neural Arch in Spondylolysis. The Journal of Bone and Joint Surgery *60 [BR]:*234-238.

Cyron BM, Hutton WC, and Troup JDG (1976) Spondylolytic Fractures. The Journal of Bone and Joint Surgery *58 [Br]:*462-466.

Davis PR (1961) Human Lower Lumbar Vertebrae: Some Mechanical and Osteological Considerations. Journal of Anatomy *95:*337-344.

De Vlam K, Mielants H, and Veys EM (1996) Association between ankylosing spondylitis and diffuse idiopathic skeletal hyperostosis: reality or fiction? Clinical and Experimental Rheumatology *14:*5-8.

di Girolamo C, Pappone N, Rengo C, Miniero E, Crisci C, and Olivieri I (2001) Intervertebral disc lesions in diffuse idiopathic skeletal hyperostosis (DISH). Clinical and Experimental Rheumatology *19:*310-312.

Dubos R (1965) Man Adapting. New Haven: Yale University Press.

Dumond DE (2000) The Norton Tradition. Arctic Anthropology *37*:1-22.

Fidas A, MacDonald HL, Elton RA, Wild SR, Chisholm GD, and Scott R (1987) Prevalence and Patterns of Spina Bifida Occulta in 2707 Normal Adults. Clinical Radiology *38*:537-542.

Flood T, Brewster M, Harris J, Keefer S, Merz R, Howe H, Hanson J, Panny S, Bakewell J, Seeland M, Costa P, Murray A, Marazita M, and Hill C (1992) Spina bifida incidence at birth--United States. JAMA *268*:708-709.

Forestier J, and Lagier R (1971) Ankylosing hyperostosis of the spine. Clinical Orthopaedics *74*:65-83.

Fortuine R (1989) Chills and Fever: Health and Disease in the Early History of Alaska: University of Alaska Press.

Fredrickson BE, Baker D, McHolick WJ, Yuan HA, and Lubicky JP (1984) The Natural History of Spondylolysis and Spondylolisthesis. The Journal of Bone and Joint Surgery *66 [Am]*:699-707.

Friberg S (1938) Studies on spondylolisthesis. Acta Chirurgica Scandinavica. Supplementum *Suppl. 52-55*:1-140.

Giddings JL (1949) Early Flint Horizons on the North Bering Sea Coast. Journal of the Washington Academy of Sciences *39*:85-90.

Giddings JL (1951) The Denbigh Flint complex. American Antiquity *16*:193-203.

Giddings JL (1960) The Archeology of Bering Strait. Current Anthropology *1*:121-138.

Gilmour JR (1941) The essential identity of the Klippel-Feil syndrome and iniencephaly. Journal of Pathology and Bacteriology *53:*117-131.

Goodman AH (1993) On the interpretation of health from skeletal remains. Current Anthropology *34:*281-288.

Gorlin RJ, and Pindborg JJ (1964) Syndromes of the Head and Neck. New York: McGraw-Hill.

Griffin D (2001) Nunivak Island, Alaska: A history of contact and trade. Alaska Journal of Anthropology *1:*77-99.

Gunness-Hey M (1981) Spondylolysis in the Koniag Eskimo Vertebral Column. In DL Martin and MP Bumsted (eds.): Biocultural Adaptation Comprehensive Approaches to Skeletal Analysis. Amherst, MA: Department of Anthropology, University of Massachusetts at Amherst, pp. 16-23.

Gunness-Hey M (1982) The Koniag Eskimo presacral vertebral column: Variations, anomalies and pathologies. Ossa *7:*99-118.

Hadley LA (1963) Stress Fracture With Spondylolysis. The American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine *90:*1258-1262.

Haukipuro K, Keranen N, Koivisto E, Lindholm R, Norio R, and Punto L (1978) Familial occurrence of lumbar spondylolysis and spondylolisthesis. Clinical genetics *13:*471-476.

Heinbecker P (1928) Studies on the metabolism of Eskimos. Journal of Biological Chemistry *80:*461-475.

Hensinger RN (1989) Current Concepts Review: Spondylolysis and Spondylolisthesis in Children and Adults. The Journal of Bone and Joint Surgery *71 [Am]:*1098-1107.

Hrdlicka A (1930) Anthropological survey in Alaska. Bureau of American Ethnology, 46th Annual Report. Washington, pp. 19-374.

Ichikawa N, Ohara Y, Morishita T, Taniguichi Y, Koshikawa A, and Matsukura N (1982) An Aetiological Study on Spondylolysis from a Biomechanical Aspect. British Journal of Sports Medicine *16:*135-141.

Jurmain RD (1977) Stress and the etiology of osteoarthritis. American Journal of Physical Anthropology *46:*353-366.

Kettelkamp DB, and Wright DG (1971) Spondylolysis in the Alaskan Eskimo. The Journal of Bone and Joint Surgery *53-A:*563-566.

Kleinberg S (1934) Spondylolisthesis in an infant. The journal of bone and joint surgery *16:*441-444.

Koutsky K (1981) Early Days on Norton Sound and Bering Strait: An overview of historic sites in the BSNC region. Volume IV: The Nome, Fish River, and Golovin Areas. Fairbanks: Anthropology and Historic Preservation Cooperative Park Studies Unit.

Krenz J, and Troup JDG (1973) The Structure of the Pars Interarticularis of the Lower Lumbar Vertebrae and its Relation to the Etiology of Spondylolysis. The Journal of Bone and Joint Surgery *55 [Br]:*735-741.

Krogh A, and Krogh M (1913) A study of the diet and metabolism of Eskimos undertaken in 1908 on an expedition to Greenland. Meddelelser om Gronland *51*:1-52.

Krogman WM, and Iscan MY (1986) The Human Skeleton in Forensic Medicine. Springfield, IL: Charles C. Thomas.

Lanier RRJ (1939) The Presacral Vertebrae of American White and Negro Males. American Journal of Physical Anthropology *25*:341-420.

Lanier RRJ (1954) Some Factors to be considered in the Study of Lumbosacral Fusion. American Journal of Physical Anthropology *12*:363-371.

Lantis M (1946) The social culture of the Nunivak Eskimo. Transactions of the American Philosophical Society *35*:153-323.

Lantis M (1972) Factionalism and Leadership: A case study of Nunivak Island. Arctic Anthropology *9*:43-65.

Lantis M (1984) Nunivak Eskimo. In D Damas (ed.): Handbook of North American Indians, Volume 5, Arctic. Washington: Smithsonian Institution, pp. 209-223.

Laurence KM (1967) The Genetics of Spina Bifida Occulta. Developmental Medicine and Child Neurology *9*:645-646.

Legge SS (2000) Effects of age and gender on the frequencies of spondylolysis and spina bifida occulta in a skeletal collection from Golovin Bay, Alaska. American Journal of Physical Anthropology *Supple. 30*:208 (Abstr.).

Legge SS (2001) A comparison of spinal pathologies in northern and southern native Alaskan skeletal populations. American Journal of Physical Anthropology *Supple. 32*:96-97 (Abstr.).

Lester CW, and Shapiro HL (1968) Vertebral Arch Defects in the Lumbar Vertebrae of Pre-historic American Eskimos: A Study of the Skeletons in the American Museum of Natural History, Chiefly from Point Hope, Alaska. American Journal of Physical Anthropology *28*:43-48.

Lorber J, and Levick K (1967) Spina bifida cystica; incidence of spina bifida occulta in parents and controls. Archives of Diseases of Childhood *42*:171.

MacMahon B, and Pugh TH (1970) Epidemiology. Boston: Brown Little.

Madrigal L (1999) Statistics for Anthropology. Cambridge: Cambridge University Press.

Mason OK, and Gerlach SC (1995) Chukchi Hotspots, Paleo-Polynyas, and Caribou Crashes: Climatic and Ecological Dimensions of North Alaska Prehistory. Arctic Anthropology *32*:101-130.

McKusick VA (1992) Medelian Inheritance in Man: Catalogs of Autosomal Dominant, Autosomal Recessive, and X-Linked Phenotypes. Baltimore: The Johns Hopkins University.

Merbs CF (1974) The effects of cranial and caudal shift in the vertebral columns of northern populations. Arctic anthropology *XI*:12-19.

Merbs CF (1983) Patterns of Activity-Induced Pathology in a Canadian Inuit Population. Ottawa: National Museums of Canada.

Merbs CF (1989) Trauma. In MY Iscan and KAR Kennedy (eds.): Reconstruction of Life from the Skeleton. New York: Wiley-Liss, pp. 161-189.

Merbs CF (1995) Incomplete Spondylolysis and Healing: A Study of Ancient Canadian Eskimo Skeletons. Spine *20:*2328-2334.

Merbs CF (1996) Spondylolysis of the Sacrum in Alaskan and Canadian Inuit. American journal of physical anthropology *101:*357-368.

Merbs CF (2002) Asymmetrical Spondylolysis. American Journal of Physical Anthropology *119:*156-174.

Merbs CF, and Wilson WH (1960) Anomalies and pathologies of the Sadlermiut Eskimo vertebral column. Contributions to Anthropology, National Museum of Canada, Bulletin *180:*154-180.

Meyerding HW (1931) Spondylolisthesis. The Journal of Bone and Joint Surgery *13:*39-48.

Miller JR, Fraser FC, and McEwan DW (1962) The frequency of spina bifida occulta and rib anomalies in the parents of children with spina bifida aperta and meningococele. American Journal of Human Genetics *14:*245-248.

Morse D (1978) Ancient Disease in the Midwest. Springfield: Illinois State Museum Reports of Investigations.

Münster JK, and Troup JDG (1973) The structure of the pars interarticularis of the lower lumbar vertebrae and its relation to the etiology of spondylolysis. Journal of Bone and Joint Surgery *55 [Br]:*735-741.

Murray MS, Robertson AC, and Ferrara R (In Review) Chronology, Culture, and Climate: A radiometric re-evaluation of late prehistoric occupations at Cape Denbigh, Alaska. Arctic Anthropology.

NAGPRA (1990) Native American Graves Protection and Repatriation Act. Public Law 101-601. United States Code Title 25, Chapter 32, Section 3001 et seq.

Newman PH (1959) Low Back Pain. In R Nassim and HJ Burrows (eds.): Modern Trends in Diseases of the Vertebral Column. New York: Paul E. Hoeber, pp. 263-280.

Newman PH (1963) The Etiology of Spondylolisthesis. The journal of bone and joint surgery *45-B*:39-59.

Nowak M (1970) A Preliminary Report on the Archeology of Nunivak Island, Alaska. Anthropological Papers of the University of Alaska *15*:18-32.

Nowak M (1982) The Norton Period of Nunivak Island: Internal change and external influence. Arctic Anthropology *19*:75-91.

Nowak M (1986) Post Norton Nunivak: A study in coastal adaptation. In RD Shaw, RK Harritt and DE Dumond (eds.): Late Prehistoric Development of Alaska's Native People. Anchorage: Alaska Historical Commission.

Ortner DJ (1968) Description and classification of degenerative bone changes in the distal joint surfaces of the humerus. American Journal of Physical Anthropology *28*:139-156.

Ortner DJ (1992) Skeletal paleopathology: Probabilities, possibilities, and impossibilities. In JW Verano and DH Ubelaker (eds.): Disease and Demography in the Americas. Washington, D.C.: Smithsonian Institution Press, pp. 5-13.

Ortner DJ, and Putschar WGJ (1985) Identification of the Pathological Conditions in Human Skeletal Remains. Washington D.C.: Smithsonian Institution Press.

Post RH (1966) Pilot Study: Population differences in the frequency of spina bifida occulta. Eugenics Quarterly *14*:341-352.

Pratt KL (2001) The ethnohistory of caribou hunting and interior land use on Nunivak Island. Alaska Journal of Anthropology *1*:28-55.

Ray DJ (1964) Nineteenth Century Settlement and Subsistence Patterns in Bering Strait. Arctic Anthropology *2*:61-94.

Ray DJ (1975) The Eskimos of Bering Strait, 1650-1898. Seattle: University of Washington Press.

Ray DJ (1983) Ethnohistory in the Arctic: The Bering Strait Eskimo. Kingston: The Limestone Press.

Renner LL (1979) Pioneer Missionary to the Bering Strait Eskimos: Bellarmine Lafortune, S.J. Portland: Binford and Mort.

Resnick D, and Niwayama G (1976) Radiographic and pathologic features of spinal involvement in diffuse idiopathic skeletal hyperostosis (DISH). Radiology *119*:559-568.

Rosenberg NJ, Bargar WL, and Friedman B (1981) The Incidence of Spondylolysis and Spondylolisthesis in Nonambulatory Patients. Spine *6*:35-38.

Rothschild BM, Woods RJ, and Ortel RW (1990) Rheumatoid arthritis "in the buff": Erosive arthritis in defleshed bones. American Journal of Physical Anthropology *82*:441-449.

Saluja PG (1988) The incidence of spina bifida occulta in a historic and a modern London population. Journal of Anatomy *158*:91-93.

Saraste H (1985) The Etiology of Spondylolysis: A retrospective radiographic study. Acta Orthopaedica Scandinavica *56*:253-255.

Schmorl G, and Junghanns H (1971) The Human Spine in Health and Disease. New York: Grune & Stratton.

Schultz AH, and Strauss WLJ (1945) The Numbers of Vertebrae in Primates. Proceedings of the American Philosophical Society *89*:601-626.

Selkregg LL (1976) Alaska Regional Profiles: Northwest Region. Anchorage: Arctic Environmental Information and Data Center.

Shahriaree H, and Harkess JW (1970) A Family with Spondylolisthesis. Radiology *94*:631-633.

Shahriaree H, Sajadi K, and Rooholamini SA (1979) A Family with Spondylolisthesis. The Journal of Bone and Joint Surgery *61-A*:1256-1258.

Sheppard WL (1983) Continuity and Change in Norton Sound: Historic Sites and Their Contexts. Fairbanks: Anthropology and Historic Preservation Cooperative Parks Study Unit, University of Alaska, Fairbanks.

Simper LB (1986) Spondylolysis in Eskimo skeletons. Acta Orthopaedica Scandinavica *57*:78-80.

Sokal RR, and Rohlf FJ (1995) Biometry. New York: W.H. Freeman and Company.

Speaker S, Kingston D, and Mudar KM (1996) Inventory and assessment of human remains and associated funerary objects from Nunivak Island, Alaska, in the National Museum of Natural History. Washington, D.C.: Repatriation Office, National Museum of Natural History, Smithsonian Institution.

Spillane JD, Pallis C, and Jones AM (1957) Developmental abnormalities in the region of the foramen magnum. Brain *80*:11-49.

Stefansson V (1922) Hunters of the Great North. New York: Harcourt Brace.

Stefansson V (1969) The Friendly Arctic: The story of five years in polar regions. New York: Greenwood Press.

Stewart TD (1931) Incidence of Separate Neural Arch in the Lumbar Vertebrae of the Eskimos. American Journal of Physical Anthropology *16*:51-62.

Stewart TD (1932) The Vertebral Column of the Eskimo. American Journal of Physical Anthropology *17*:123-136.

Stewart TD (1947) Racial patterns in vertebral osteoarthritis. American Journal of Physical Anthropology *5*:230-231 (Abstr.).

Stewart TD (1953) The Age Incidence of Neural -Arch Defects in Alaskan Natives, Considered from the Standpoint of Etiology. Journal Bone and Joint Surgery *35[A]*:937-950.

Stewart TD (1956) Examination of the possibility that certain skeletal characters predispose to defects of the lumbar neural arches. Clinical Orthopaedics *8*:44-60.

Stewart TD (1973) The People of America. London: Weidenfeld and Nicolson.

Stini WA (1995) Osteoporosis in biocultural perspective. Annual Review of Anthropology *24*:397-421.

Thieme FP (1951) An anatomical relationship predisposing to lumbosacral fusion. American Journal of Physical Anthropology *9*:149-158.

Thomas CL, ed. (1981) Taber's Cyclopedic Medical Dictionary. Philadelphia: F.A. Davis Company.

Tikhmenev PA (1978) A History of the Russian-American Company. Seattle: University of Washington Press.

Tishler M, and Yaron M (1992) Two cases of diffuse idiopathic skeletal hyperostosis and ankylosing spondylitis. British Journal of Rheumatology *31*:569-571.

Todd TW (1922) Numerical significance in the thoracicolumbar vertebrae of the mammalia. Anatomical Record *24*:261-286.

U.S. Bureau of the Census (1982) General Population Characteristics, Pt. 3: Alaska, PC80-1-B3, table 55, Census of Population. Washington D.C.: U.S. Government Printing Office.

U.S. Census Bureau (2001) Census 2000, Table DP-1. Profile of General Demographic Characteristics: 2000. Wahsington D.C.: U.S. Government Printing Office.

U.S. Census Office (1893) Report on Population and Resources of Alaska at the Eleventh Census. Washington D.C.: U.S. Government Printing Office.

Ureid J, and Byrd B (1995) Physical Anthropology Laboratory Manual. Washington, DC: Repatriation Office, National Museum of Natural History, Smithsonian Institution.

VanStone JW (1957) An Archaeological Reconnaissance of Nunivak Island, Alaska. Anthropological Papers of the University of Alaska *5*:97-118.

VanStone JW (1973) V.S. Kromchenko's Coastal Explorations in Southwestern Alaska, 1822. Fieldiana: Anthropology *64*:1-95.

VanStone JW (1989) Nunivak Island Eskimo (*Yuit*) Technology and Material Culture. Fieldiana: Anthropology *New Series, No. 12*:108.

Verano JW, and Ureid J, eds. (1994) Physical Anthropology Laboratory Data Manual, Technical Reports, No. 1. Washington D.C.: Repatriation Office, National Museum of Natural History, Smithsonian Institution.

Wade WD (1981) Klippel-Feil syndrome in a prehistoric population of northern Arizona. In JS Cybulski (ed.): Contributions to Physical Anthropology, 1978-1980. Ottawa: National Museums of Canada, pp. 115-126.

Wells C (1964) Bones, Bodies and Disease. London: Thames and Hudson.

White TD (1991) Human Osteology. San Diego: Academic Press, Inc.

Willis TA (1923) The lumbo-sacral vertebral column in man, its stability of form and function. The American Journal of Anatomy *32*:95-123.

Willis TA (1929) An Analysis of Vertebral Anomalies. American Journal of Surgery *6*:163-168.

Willis TA (1931) The Separate Neural Arch. The Journal of Bone and Joint Surgery *13*:709-721.

Wiltse LL (1962) The Etiology of Spondylolisthesis. Journal of Bone and Joint Surgery *44A*:539-560.

Wiltse LL, Newman PH, and Macnab I (1976) Classification of Spondylolysis and Spondylolisthesis. Clinical Orthopaedics and Related Research *117*:23-29.

Wiltse LL, Widell EHJ, and Jackson DW (1975) Fatigue Fracture: The Basic Lesion in Isthmic Spondylolisthesis. The Journal of Bone and Joint Surgery *57-A*:17-22.

Wood JW, Milner GR, Harpending HC, and Weiss KM (1992) The osteological paradox: Problems of inferring prehistoric health from skeletal samples. Current Anthropology *33*:343-370.

Wynne-Davis R, and Scott JH (1979) Inheritance and Spondylolisthesis. Journal of Bone and Joint Surgery *61 [Br]*:301-305.

APPENDICES

A Scoring Codes from Urcid and Byrd (1995)

PATH CODE 7: VERTEBRAL PATHOLOGY

Observation 1: *Schmorl's Depressions*	Code
Present	10
Observation 2: *Vertebral Osteophytosis* (Indicate Maximum Expression) (If porosities are present around inner margins, score under Obs 6 below)	
Barely discernible	21
Elevated rim	22
Curved spicules	23
Fusion of spicules	24
Observation 3: *Syndesmophytes* (Indicate Maximum Expression)	
Barely discernible	31
Elevated rim	32
Curved spicules	33
Fusion of spicules	34
Observation 4: *Spina Bifida*	
Complete	41
Partial (when the cleft involves only the bottom of S3 and top of S4	42
Observation 5: *Spondylolysis*	
Complete fracture, no healing	51
Healing evident	52
Spondylolisthesis	53
Partial fracture, no healing	54
Observation 6: *Porosities around margins of vertebral osteophytes*	
Porosities around margins	61
Porosities within end plates	62
Porosities around margins and within end plates	63

Observation 7: *Vertebral Anomalies*	
Cervical ribs	71
Ununited components	72
Supernumerary cervical vertebrae	73
Supernumerary thoracic vertebrae	74
Supernumerary lumbar vertebrae	75
Sacralization of L5/L6	76
Lumbarization of S1	77
Accessory sacral facets	78
Observation 8: *Vertebral Body Fractures*	
Compression (non-pathological, but result of an accident or trauma)	80
Single end-plate depression without wedging	81
Single end-plate depression with wedging	82
Wedged (congenital/idiopathic only)	83
Biconcave bodies with/without wedging (reflects osteoporosis/osteomalacia)	84
More than one of the above	85
Observation 9: *Vertebral Anomalies (cont.)*	
Occipitalization of C1	90
Block vertebrae	91
Lumbarization of S2	92
Lumbar ribs	93
Sacralization of caudal vert	94
Paramastoid tubercle(s)	95

PATH CODE 8: ARTHRITIS

Observation 1: *Surface Porosity: degree*	
Barely discernible	11
Pinpoint	12
Coalesced	13
Observation 2: *Surface Porosity: portion of joint surface affected*	
Less than 1/3	21
1/3 to 2/3	22
More than 2/3	23

Observation 3: *Lipping: degree*	
Barely discernible	31
Rounded ridge	32
Sharp ridge, sometimes curled with spicules	33
Initial fusion	34
Fused	35
Observation 4: *Lipping: extent of circumference affected*	
Less than 1/3	41
1/3 to 2/3	42
More than 2/3	43
Observation 5: *Eburnation: degree*	
Barely discernible	51
Polish only	52
Polish with grooves	53
Observation 6: *Eburnation: extent of surface affected*	
Less than 1/3	61
1/3 to 2/3	62
More than 2/3	63
Observation 7: *Surface Osteophytes (see Obs 10 below)*	
Barely discernible	71
Clearly present	72
Observation 8: *Erosion*	
Barely discernible	81
Clearly present	82
Observation 9: *Extent of Erosion*	
Less than 1/3 of the joint surface affected	91
1/3 to 2/3 of the joint surface affected	92
More than 2/3 of the joint surface affected	93
Observation 10: *Extent of Surface Osteophytes*	
Less than 1/3 of the joint surface affected	101
1/3 to 2/3 of the joint surface affected	102
More than 2/3 of the joint surface affected	103

B Inventory of Individuals from Golovin Bay

CATKEY: 279208 Age: 1-4 yrs. Sex: Indeterminate

The remains of this young individual are poorly preserved. Only six fragments of unfused thoracic vertebral arches are present. No pathologies were noted for these very fragmentary remains.

CATKEY: 279209 Age: 35-49 yrs. Sex: Male

This middle adult male has 23 vertebrae and a complete sacrum present. The first lumbar vertebra (L1) is missing. Nearly all vertebrae show some signs of osteoarthritis (OA). C1 through C6 show OA of the articular facets, as well as surface osteophyte development on the bodies. C7 is unaffected. T1, T2, and T5 - T12 all exhibit OA of either the transverse processes or the costal facets. The most severe remodeling associated with OA in the thoracic region is located on the inferior aspect of T10 and the superior aspect of T11. On T10 and T11, lipping around more than three-quarters of the vertebral body was observed, along with surface osteophytes covering more than two-thirds of the surface area of the vertebral bodies. OA was observed in all lumbar vertebrae present, as well as on the superior articular facets of the first element of the sacrum. L3 and L4 exhibited hypertrophic bone development around the dorsal margins of the articular facets, but it is unclear what this was related to. L5 showed bilateral spondylolysis through *pars interarticularis* forming a pseudarthrosis on both the left and right halves. There appears to be some minor arthritic development present associated with the spondylolytic separation.

CATKEY: 279210 Age: 50+ yrs. Sex: Female

There are 23 vertebrae and a complete sacrum present for this old adult female. The vertebral count includes a sixth lumbar. Missing are the seventh cervical and second thoracic vertebrae. Osteoarthritis was observed on the articular facets of C2, C3, and T12, the bodies of all thoracic vertebrae present, and on the superior aspect of the body of the first sacral element. Syndesmophytes project inferiorly on the ventral aspect of the arches of T5 through T7. On T8 through L2 syndesmophytes extend both superiorly and inferiorly. Vertebral body osteophytes are present on L4 through L6, with severity increasing as you move caudally. L4 through L6 also all exhibit complete bilateral spondylolysis through *pars interarticularis*.

CATKEY: 333453 Age: 35-49 yrs. Sex: Male

This middle adult male includes a complete vertebral column and sacrum. No pathologies were noted in the cervical vertebrae. Among the thoracic vertebrae, OA was noted on the articular facets of T3 through T8 and around the centrum margins of T6 through T10. Schmorl's depressions are present on the superior aspects of T6, T9, and T11, as well as the inferior of T12. The only lumbar vertebra exhibiting any pathological condition is the L5, which has complete bilateral spondylolysis through *pars interarticularis* and osteophyte development around the outer margin of the vertebral body. The sacrum of this individual includes a partially separated first sacral element. Separation is complete along the midline of S1 and some osteophytes are present along the ventral margin of the body.

CATKEY: 333454 Age: 35-49 yrs. Sex: Male

There are 25 presacral vertebrae and a complete sacrum associated with this middle adult male. The extra presacral vertebra is an L6. OA was observed on all cervical vertebrae, T1 through T9, T10, and L2 through L5. Most cervical vertebrae affected showed mild to moderate porosities of the articular facets, although some osteophytic remodeling was observed around the bodies of C4 through C7. The thoracic vertebrae are generally affected with surface porosities of the articular facets. Some osteophytic remodeling is present; ranging from no expression in the upper thoracic region to slightly curved spicules around the outer margins of the vertebral bodies of the lower thoracic vertebrae. There is an apparently healed fracture of the spinous process of T5 in this individual. There is some callous bone formation and the bone healed slightly misaligned. Porosities are present on the articular facets of L2 through L5 and some osteophytic development is present around the bodies, increasing in severity caudally. L6 in this individual has become sacralized and also shows unilateral spondylolysis through the right side at *pars interarticularis*. Complete spina bifida is also present beginning at L6 and extending through the entire sacrum.

CATKEY: 342420 Age: 20-34 yrs. Sex: Female

This young adult female includes a complete 24 element vertebral column as well as a complete sacrum. Very few pathologies were noted in this well preserved skeleton. There is a small amount of lipping around the vertebral bodies, as well as slight osteophyte development around both the superior and inferior articular facets of L2 through L4. This individual still contained some soft tissue and C7 through L1 are all articulated by connective tissues.

CATKEY: 342421 Age: 20-34 yrs. Sex: Female

Only three cervical vertebrae (C1 – C3) are associated with this young adult female. Some desiccated tissue is still attached to all three vertebrae. No pathologies or anomalies are evident.

CATKEY: 346001 Age: 35-49 yrs. Sex: Male

Extensive osteoarthritic remodeling is present throughout the complete vertebral column and sacrum of this middle adult male. The only vertebra that appears to be unaffected is C1. Involvement of both the vertebral bodies and articular facets is present on C2 through C7, although the severity appears to increase caudally. Moderate to severe OA is present in all thoracic vertebrae, however the mid-thoracic vertebrae (T3 – T9) appear to be the most severely affected. The costal facets are affected by osteoarthritic porosities on T1, T2, T5, and T7 – T9. The lumbar vertebrae all exhibit OA on both the superior and inferior bodies. L3 and L5 also show OA involvement of the superior articular facets. Spondylolysis is present in both L4 and L5. L4 exhibits complete bilateral separation through *pars interarticularis*, while L5 shows complete separation through pars on the right side and partial separation through the pedicle on the left side. The left transverse process has become slightly truncated with some remodeling of both the transverse process and the pedicle. Both the L4 and L5 also exhibit slight compression of the centrum. The sacrum shows OA of both the articular facets and body of S1. Lumbarization of the first sacral element is present and it appears that the second sacral element has also begun to take on lumbar characteristics. The first coccygeal vertebra is also fused to the sacrum.

CATKEY: 346004 Age: 35-49 yrs. Sex: Female

This middle adult female includes a complete 25 element vertebral column (L6 present) and a complete sacrum. All of the cervical vertebrae are severely affected by OA. Extensive remodeling of the inferior articular facets of C2, and both the superior and inferior articular facets of C3 and C4 is present. Eburnation is present on the bodies of both C4 and C5, giving evidence of prolonged bone to bone contact at this location. The lower cervical vertebrae are not as affected and the first two thoracic vertebrae do not appear to have any osteoarthritic remodeling present. OA is present on both the bodies and articular facets of T3 through T12 and increases in severity caudally. Severe osteophyte development is noted on both T12 and L1, and it appears that these two vertebrae may have been fused antemortem. T12 and L1 also exhibit single endplate depression with slight wedging. L1 through L6 are all affected by osteoarthritic remodeling, although the mid-lumbar vertebrae, L2 – L4, appear to be the least severely affected. A costal facet is present on the left side of L1 along with a lumbar rib. No rib is present on the right side and a possible costal facet is partially eroded taphonomically. OA extends to the superior body of the first sacral element, where coalesced surface porosities and surface osteophytes are present.

CATKEY: 346006 Age: 20-34 yrs. Sex: Female

Only C1 and C2 are missing from the vertebral column of this well preserved young female. No pathologies are present in any of the vertebrae and the only anomaly observed is the partial lumbarization of the first sacral element.

CATKEY: 346007 Age: 15-19 yrs. Sex: Ambiguous subadult

The only vertebrae present for this late adolescent were one unknown cervical vertebra, T1 through T10, and one unknown lumbar vertebra. No pathologies were noted among any of the vertebrae present.

CATKEY: 346008 Age: 35-49 yrs. Sex: Female

Most of the remains of this middle adult female are severely eroded taphonomically. The only identifiable vertebrae are C1, L2, and L3. All three of these vertebrae exhibit osteoarthritic remodeling. C1 shows OA on the superior articular facets, as well as along the superior aspect of the articulation with the odontoid process of C2. Both lumbar vertebrae exhibit osteophytic development around the margins of the bodies. A partial sacrum is also included with these remains, but it is badly eroded and no observations are possible.

CATKEY: 346009 Age: 10-14 yrs. Sex: Indeterminate

Fragmentary portions of T10 – L3, L5, and one unknown mid-thoracic vertebra are present for this young individual. The only pathology observed was OA, in the form of porosities, on the left inferior articular facet of the single unknown mid-thoracic vertebra. A fragment of sacrum is also present, but pathological observations are not possible.

CATKEY: 346010 Age: 20-34 yrs. Sex: Female

This young adult female includes a complete 24 element vertebral column and sacrum. There are no pathologies present in the cervical vertebrae of this individual. However, vertebral osteophytosis and syndesmophyte development is present throughout the thoracic segment, increasing in severity caudally. Single end plate depression with wedging is also present in both T11 and T12. Possibly associated with the wedging is the presence of a small Schmorl's node along the posterior margin of the superior surface of the body of L1. Osteophytosis and syndesmophyte development are also present in the lumbar segment, however they decrease in severity caudally.

CATKEY: 346011 Age: 20-34 yrs. Sex: Male

A complete 24 element vertebral column and sacrum are present for this young adult male. The cervical vertebrae exhibit several interesting pathologies and anomalies. C1 shows abnormal bone growth of the inferior articular facets, such that the medial margins articulate with the odontoid process of C2, forming accessory facets. The odontoid process of C2 is angled toward the left and some remodeling of the superior articular facets has occurred to compensate for this angle. There is also some osteoarthritic remodeling present on the superior articular facets of C2, including porosities and some slight eburnation. No other cervical vertebrae exhibit pathologies. In the thoracic vertebrae, OA is present on T1, T2, and T5 through T12, increasing in severity caudally. Osteoarthritic remodeling is present on the articular facets, as well as the costal facets in all thoracic vertebrae affected. Lumbarization of T12 has occurred in the form of a change in the orientation of the superior articular facets and changes in the transverse processes to resemble those of a lumbar vertebra. Among the lumbar vertebrae, L1 and L2 exhibit osteoarthritic remodeling of the superior articular facets. The only other anomaly observed in the lumbar segment is the partial sacralization of L5. Remodeling has occurred in the transverse processes of L5, making them resemble the ala of the sacrum, but no ankylosing has occurred between the two. No pathologies or anomalies are present on the sacrum.

CATKEY: 346012 Age: 35-49 yrs. Sex: Male

This young adult male includes 21 presacral vertebral elements and a complete sacrum. All seven cervical vertebrae are present and all are affected by OA. C1 through C3, and

C7 all show remodeling of the articular facets. C2 also has severe osteoarthritic change around the odontoid process, with eburnation present on the anterior surface. C4 through C6 exhibit OA on the articular facets as well as the bodies of each vertebra. OA is present throughout the entire thoracic segment, including remodeling of the articular facets, in addition to syndesmophyte development around the bodies. Schmorl's nodes are present on both the superior and inferior aspects of the body of T6, both of which penetrate the outer table of bone. Slight depressions are also evident on the inferior body of T5 and the superior body of T7. T6 also exhibits endplate depression, with wedging of the body. In the lumbar segment only the L1 and a single unidentified lumbar vertebra are present. L1 exhibits OA remodeling on all four articular facets and some osteophytic development around the body. No pathologies are noted on the sacrum.

CATKEY: 346013A Age: 35-49 yrs. Sex: Female

There are 24 presacral vertebrae and a complete sacrum associated with this middle adult female. The cervical vertebrae exhibit OA only on the articulations of C1 through C5. Within the thoracic region osteoarthritic remodeling is present on the inferior facets of T1, the costal facets of T4, the right inferior facet of T6, the right superior facet of T7, the right inferior facet of T8, both costal facets of T9, and the both inferior facets and the right costal facet of T12. Among the lumbar vertebrae, only L1 exhibits OA, which is seen on all four articular facets. The sacrum in this individual is complete, but it suffers from moderate taphonomic erosion, making complete assessment of pathologic conditions difficult. It appears that there may be incomplete union of the spinous process of S1, but it is not completely clear because of the condition of the bone.

CATKEY: 346014 Age: 50+ yrs. Sex: Male

This old adult male has a 24 element presacral vertebral column and a complete sacrum. Severe osteoarthritic remodeling is present throughout the entire vertebral column. The cervical vertebrae exhibit remodeling of both the articular facets and bodies. C1 and C2 show eburnation of the inferior and superior articular facets respectively, reflecting long-term bone on bone contact. The vertebral bodies of C2 through C6 are remodeled to such an extent as to give the impression of semi-interlocking centrums. Slight eburnation is also present on the left superior and inferior articular facets of C4. In the thoracic region, all articular facets have been affected by OA and the costal facets of T1, T2, T5, and T7 – T10 show osteoarthritic remodeling. L1 through L3 have all been glued together along the superior and inferior articular facets. Severe osteophyte development is present on all lumbar vertebrae, resulting in overlapping margins between the vertebrae. Complete bilateral spondylolysis is present on L5, with separation through *pars interarticularis* on the left side and through the pedicle on the right. On the sacrum, S1 exhibits osteophytic development around the superior margin of the body. S1 also shows signs of lumbarization.

CATKEY: 346015 Age: 20-34 yrs. Sex: Male

There is a complete 24 element presacral vertebral column and a complete sacrum associated with this young adult male. No OA or other pathologies were noted for nearly the entire column. L5 exhibited complete bilateral spondylolysis, through *pars interarticularis* on the right side and through the lamina on the left. Osteoarthritic remodeling was present around the separation sites on both sides. No other anomalies or pathologies were noted.

CATKEY: 346016 Age: 35-49 yrs. Sex: Female

The vertebral column of this middle adult female is comprised of C7 through L5, two unknown mid-cervical vertebrae, and a complete sacrum. No anomalies or pathologies are present in the cervical vertebrae. The thoracic vertebrae exhibit mild syndesmophyte development that increases in severity caudally. The lumbar vertebrae all show considerably more syndesmophyte development than the thoracic segment, although it lessens in severity caudally. Osteophytic remodeling is also present throughout the lumbar vertebrae, increasing in severity caudally. Lumbar rib facets are also present bilaterally on L1. Complete bilateral spondylolysis is present on L5, with separation through *pars interarticularis* on both sides of the neural arch. On the sacrum it appears as if the first coccygeal element was fused to the sacrum antemortem, but it has been separated from the sacrum by postdepositional breakage.

CATKEY: 346018 Age: 35-49 yrs. Sex: Male

There are 22 presacral vertebrae associated with this middle adult male. The only two vertebrae missing are C4 and C5. A complete sacrum is also included with these remains. Osteoarthritic remodeling is present in all of the cervical vertebrae present. C1 exhibits OA on the facet for the odontoid process, while C2 shows OA on the odontoid process itself. C3 has remodeling of both inferior articular facets and OA is limited to the articular facets of both C6 and C7. Some ankylosing has taken place between the bodies and laminae of C2 and C3. It appears that this is associated with a congenital condition, such as Klippel-Feil syndrome. In the thoracic region, osteophytic development around the vertebral bodies, and syndesmophytes are both present from T4 through T12, increasing in severity caudally. The articular facets of T11 and T12 have also been affected by OA. In the lumbar segment, all vertebrae exhibit osteoarthritic remodeling of the articular facets. L2 and L3 have barely discernible osteophytic development around the margins of the bodies, while L4 has very well developed osteophytosis. L1 has well developed bilateral lumbar rib facets. Both L1 and L2 show compression in the form of single end plate depression with wedging. Complete bilateral spondylolysis through *pars interarticularis* is present on L3, L4, and L5. The separated portions of the neural arches have formed pseudarthroses, with slight eburnation of the articulating ends. The sacrum exhibits osteophytosis around the margin of S1. The first coccygeal element has also fused to the sacrum.

CATKEY: 346019 Age: 35-49 yrs. Sex: Male

This middle adult male includes a complete 24 element vertebral column and sacrum. Osteoarthritic remodeling is present in the cervical vertebrae, but is limited to the articular facets beginning with the inferior facets of C2 and extending down through the inferior facets of C4. Each is characterized by a small number of coalesced porosities and minor lipping around the edges of the articular facets. OA is seen in T1 through T10 and T12 in the thoracic region. Most of the remodeling is located on the articular facets, although T4 through T9 exhibit some OA on the costal facets of the transverse processes. There is very little osteophyte development in the thoracic region. No osteoarthritic remodeling is noted in the lumbar segment of the column, but there is mild osteophyte development of L1 through L4. L5 exhibits relatively severe osteophytic change around the inferior border of the body. This change in L5 may be due to the complete bilateral spondylolysis through *pars interarticularis* that is present. Osteophyte development is also present on the superior margin of the body of the first sacral element. The first sacral element is partially sacralized with some separation of the body from S2 and the formation of inferior articular facets, as well as remodeling of the ala to resemble transverse processes.

CATKEY: 346020 Age: 15-19 yrs. Sex: Indeterminate

The remains of this late adolescent include 22 presacral vertebrae and a complete sacrum. The vertebrae present are C1, C2, T1 through L5, and two unidentified cervical vertebrae. No pathologies or anomalies were noted in any vertebrae of this young individual.

CATKEY: 346021 Age: 35-49 yrs. Sex: Male

This middle adult male includes a complete 24 element presacral vertebral column and sacrum. There is very little osteoarthritic remodeling throughout the column. In the thoracic region T4 through T7 exhibit OA on the costal facets of the transverse processes. Some remodeling has also taken place around the bodies and articular facets of L1 and L2. In the cervical region, ankylosing is present between the inferior facets of

C2 and the superior facets of C3, forming a block vertebra. There were no other pathologies noted in this portion of the column, leading to the belief that this condition was congenital, rather than a pathologically induced. Also of note in this individual is complete bilateral spondylolysis of L5 through *pars interarticularis*. The sacrum exhibited some apposition of woven bone on the left ala along the superior aspect of the dorsal surface. There is healing and remodeling evident that would indicate a localized infection. Similar bone remodeling is also present on the left innominate supporting the conclusion that a localized infection was the cause of the new bone apposition.

CATKEY: 346022A Age: 20-34 yrs. Sex: Female

There is a complete 24 element vertebral column and complete sacrum associated with this young adult female. In the cervical segment, only C1 shows OA. There is some lipping with bony spicules on the superior margin of the articulation with the odontoid process of C2. All of the thoracic vertebrae exhibit osteoarthritic remodeling of the costal facets of both the vertebral bodies and the transverse processes. The extent of the changes range from barely discernible to mild expression, with the most pronounced changes in the mid-thoracic vertebrae. No OA is present in the lumbar vertebrae, however complete unilateral spondylolysis through the right *pars interarticularis* of L1 is present. No pathologies of the sacrum are present.

CATKEY: 346025 Age: 5-9 yrs. Sex: Indeterminate

This young child includes 9 unfused vertebrae and a partial sacrum. There are neural arches five unidentified thoracic vertebrae and bodies and arches from four unidentified lumbar vertebrae. No pathologies were noted in the fragmentary vertebrae of this young individual. The fragment of sacrum is also small and no observations are possible.

CATKEY: 346026 Age: 1-4 yrs. Sex: Indeterminate

There are only fragments of 9 vertebrae associated with this very young individual. One complete and one fragmentary neural arch make up the cervical vertebrae present. The thoracic vertebrae are represented by three unidentified complete neural arches and the lumbar vertebrae include two complete unidentified centrums and four neural arches. No pathologies were observed on these fragmentary remains. There was no sacrum present.

CATKEY: 346028 Age: 50+ yrs. Sex: Female

This old adult female included one unidentified cervical vertebra, C7, T1 through L5, and a fragmentary sacrum. No pathologies were noted on C7. Osteoarthritic remodeling is present on both inferior articular facets of T1, as well as the costal facets of the body and transverse processes. Osteophyte development is present from T6 through T12, in the thoracic segment, increasing in severity caudally. The inferior articular facets of T10, T11, and T12 have also undergone remodeling. Numerous Schmorl's nodes are present in the thoracic segment, including on the inferior body of T7, and the superior bodies of T9, T10, T11, and T12. Single end plate depression with wedging is also present on T6, T9, T10, T11, and T12. Compression of these vertebrae is most likely related to osteoporosis, as these remains are light weight with extremely thin cortical bone throughout the skeleton. In the lumbar segment OA is present around the margins of the bodies of all the lumbar vertebrae. Schmorl's nodes are present on the superior and inferior bodies of both L1 and L2, and on the superior bodies of L3 and L4. The fragmentary sacrum is badly eroded taphonomically, and S1 through S5 are all missing.

CATKEY: 346029 Age: 50+ yrs. Sex: Female

There are 21 presacral vertebrae and a fragmentary sacrum associated with this old adult female. There is marked OA throughout all of the vertebral elements present. In the cervical segment, all seven cervical vertebrae exhibit porosities and remodeling around the bodies and articular facets, associated with OA. In the thoracic segment, only T1 through T9, and T12 are present. Nearly all the articular facets of the thoracic vertebrae show signs of OA. There are also elevated rings of bone around the superior and inferior margins of the bodies of all of the thoracic vertebrae present, increasing in size caudally. All lumbar vertebrae, except L2 are present. OA remodeling around the bodies of all the lumbar vertebrae is present, increasing in severity caudally. L5 exhibits the worst osteoarthritic development of the lumbar vertebrae, with major remodeling of all four articular facets. A single Schmorl's node is located on the superior aspect, near the left center of the body of L1. There is also some anterior wedging of L1. The fragmentary sacrum exhibits OA along the anterior margin of the body and on both superior articular facets of S1. *Spina bifida occulta* is present, represented by the incomplete fusion of the spinous process of S1. It appears that S1 is also partially lumbarized, based on the noticeable separation of the right lamina of S1 from that of S2.

CATKEY: 346030A Age: 5-9 yrs. Sex: Indeterminate

The fragmentary remains of this child include a single cervical vertebra (C7), T12, one unidentified thoracic vertebra, L1, L2, and L5. The neural arches are fused to the bodies in all but the unidentified thoracic vertebra, but the epiphyses are not present for any vertebrae. A fragmentary sacrum is also present. No pathologies or anomalies are visible on these very fragmentary remains.

CATKEY: 346031 Age: 5-9 yrs. Sex: Indeterminate

There is a nearly complete vertebral column, missing only L5, and a fragmentary sacrum associated with the remains of this child. All neural arches are fused to the bodies. No pathologies or anomalies are noted for this individual.

CATKEY: 346033 Age: 15-19 yrs. Sex: Probable male

The vertebral column of this late adolescent is comprised of six cervical vertebrae, missing only C7, eleven thoracic vertebrae, missing T1, and all five lumbar vertebrae. Also included is a fragmentary sacrum. C3 and C4 of this individual exhibit congenital fusion (segmentation failure) (Figure 15), most likely associated with Klippel-Feil syndrome (Aufderheide and Rodríguez-Martín, 1998). These two vertebrae are attached on the left side at the laminae and partially fused on the right side at the same place. Preservation of these remains is good and no other pathologies or anomalies are present.

CATKEY: 346035 Age: 10-14 yrs. Sex: Indeterminate

There is a complete 24 element vertebral column and sacrum associated with this adolescent. All neural arches had fused to the bodies by the time of death. Bone preservation was excellent, with no weathering evident. No pathologies or anomalies were noted.

CATKEY: 346108 Age: 35-49 yrs. Sex: Male

Only C1 through C6, and a fragmentary sacrum are present from this middle adult male. Osteoarthritis was noted in C1 and C2, including eburnation with grooves on the left inferior articular facet of C1 and left superior facet of C2. No other pathologies were noted in the vertebrae, however this individual was badly weathered, making determinations of pathologies around the bodies of the vertebrae difficult. Although the sacrum is fragmentary, it appears that S1 is partially lumbarized.

CATKEY: 346109 Age: 10-14 yrs. Sex: Indeterminate

A complete 24 element vertebral column and partial sacrum comprise the vertebral remains of this adolescent. All neural arches are fused to the bodies. There is only one vertebral anomaly present in this individual. T7 exhibits depressions on both the superior and inferior aspects of the body that resemble Schmorl's nodes, but do not appear to be related to intervertebral disc herniation. The body of T7 shows some wedging with slight separation of the centrum at the midline (see Figure 21). It is possible that this is a sagitally cleft centrum as described by Barnes (1994). The condition is a developmental anomaly that is genetic in origin. No other vertebrae in the column are affected with this condition and there are no other indications of pathology in the remainder of the vertebrae present.

CATKEY: 346110 Age: 20-34 yrs. Sex: Female

Although all 24 presacral vertebrae and a partial sacrum are present in this young adult female, weathering has badly eroded the remains, making many observations impossible. Complete C1 and C7 are present, but C2 through C6 are fragmentary. In the thoracic region, all thoracic vertebrae are present. Mild OA development is present on the superior and inferior body surfaces of T1 through T10, both T11 and T12 are unobservable because of weathering. Syndesmophyte development is also present on the neural arches of T4 through T8. No pathologies are present in the lumbar vertebrae, but the first sacral element seems to have undergone partial lumbarization.

CATKEY: 346112 Age: 15-19 yrs. Sex: Indeterminate

The remains of this late adolescent include C1 through C5, five unidentified mid-thoracic, and 3 unidentified lumbar vertebrae. Also included is a fragmentary sacrum. No pathologies are noted for the fragmentary remains of this subadult.

CATKEY: 346113A Age: 35-49 yrs. Sex: Male

The presacral vertebral column of this middle adult male has only T6 through L5 present. A complete sacrum also accompanies these remains. OA is present on the articular facets of T7 through T12, increasing in severity caudally. Schmorl's nodes are also present on the inferior body of T7, as well as the inferior and superior bodies of T8 through T12. There is also increasing osteophyte development from T7 through T12. In the lumbar segment, the left superior facet of L1, left inferior facet of L2, and the left and right inferior facets of L3 and L4 all show osteoarthritic remodeling. Schmorl's nodes are present of the superior bodies of L1, L2, and L3. Osteophyte development is most severe at L3, however, L1, L2, and L4 are also affected. No pathologies are present on the sacrum.

CATKEY: 346114 Age: 15-19 yrs. Sex: Ambiguous subadult

All vertebral elements for this late adolescent are fragmentary, as is the sacrum. The vertebrae include eight unidentified thoracic and three unidentified lumbar. No pathologies or anomalies are apparent on this very fragmentary subadult.

CATKEY: 346117A Age: 20-34 yrs. Sex: Male

This young adult male exhibits major remodeling of nearly every vertebral element. All 24 presacral vertebrae are present, along with a complete sacrum. Osteoarthritic remodeling is present throughout all of the cervical vertebrae. C2 and C3 have extreme osteophyte development, to the point of nearly ankylosing together. C7 is fused to T1 through extreme osteophyte development. The entire upper thoracic region is completely fused, including C7 through T7, and T10 is fused to T11. Although, it appears that the entire thoracic segment and most of the lumbar segment had been fused perimortem. Postmortem breakage is the most likely cause for the separation of these segments. Several ribs, including right and left R1, R2, R5, and R7 are all fused to the corresponding thoracic vertebrae. In addition, the left R3, R6, and R9 are also fused. All other ribs present show incipient fusion. In the lumbar segment, L1 and L2 are still attached via osteophyte development of the lateral margins. Osteophyte development appears to be most pronounced on the left lateral aspect of the lumbar vertebrae. L3, L4, and L5 all show extreme osteophyte development and appear to have been fused perimortem. Diagnosis of the particular pathology is slightly problematic. Ortner and Putschar (1985) examined this same individual and came to the conclusion that it was most likely a case of rheumatoid arthritis, although ankylosing spondylitis could not be completely ruled out. My analysis of this individual is in agreement with their findings. Involvement of most of the vertebral elements, degeneration of other joints, including severe OA in both knees and some new bone development in the elbow, coupled with the lack of fusion of the sacroiliac all point to a diagnosis of rheumatoid arthritis.

CATKEY: 346131 Age: Indeterminate Adult Sex: Ambiguous

A single lumbar vertebra and partial sacrum are the only vertebral elements present for this adult. The lone vertebra is L5 and exhibits complete bilateral spondylolysis through *pars interarticularis*. There are also minor vertebral osteophytes around the margin of the body of this vertebra. The fragmentary sacrum exhibits partial lumbarization of S1. No other pathologies are noted.

CATKEY: 352353 Age: 20-34 yrs. Sex: Female

This young adult female has 14 presacral vertebrae and no sacrum. The vertebrae include a C1 and two unidentified cervical vertebrae, T1 through T9, and T11. No pathologies are present on the cervical vertebrae, but all thoracic vertebrae present exhibit OA on nearly all superior and inferior articular facets. The single unidentified lumbar vertebra show moderate osteoarthritic remodeling of all four articular facets.

CATKEY: 352359 Age: 20-34 yrs. Sex: Female

T3 through T12 and two unidentified lumbar vertebrae are present in the remains of this young adult female. No pathologies are noted in the fragmentary remains of this individual.

CATKEY: 352369 Age: 20-34 yrs. Sex: Male

There are 23 presacral vertebrae (missing only C7) and a complete sacrum associated with this young adult male. The cervical vertebrae exhibit OA on the right and left superior facets of C3, the left inferior facet of C3, the left superior facet of C4, and the right superior facet of C6. The spinous process of C2 is partially bifurcated, although there is no indication of pathology associated with this condition. The transverse processes of C5 and C6 appear to be misshapen, possibly due to a developmental anomaly during fusion of the neural arches to the vertebral bodies. In the thoracic segment of the column, T1 shows osteoarthritic remodeling of the right costal facet on the transverse process and the right and left costal facets on the body. T4 and T5 show remodeling of the right inferior and superior facets respectively. OA is present on the left costal facet of the transverse process and the left and right inferior facets of T8. T9 has remodeling of the left costal facet on the transverse process, and T10 has changes of the left and right inferior facets. Both T11 and T12 exhibit changes associated with OA on all four articular facets. In the lumbar segment, OA is present on the right and left superior facets of L1 and L4, and the right and left inferior facets of L3. L4 also exhibits complete bilateral spondylolysis through *pars interarticularis*. Associated with the spondylolytic separation is a pseudarthrosis on the left side with some eburnation resulting from the bone on bone contact. In the sacrum, partial lumbarization of S1 is present.

CATKEY: 352370A Age: 35-49 yrs. Sex: Female

The fifth cervical vertebra is the only presacral element missing from this middle adult female. A complete sacrum is also present in the remains. In the cervical vertebrae, the right superior facet of C4, right and left superior facets of C6, and the right and left inferior facets of C7 all show osteoarthritic remodeling. The thoracic vertebrae exhibit remodeling of nearly all costal facets on the vertebral bodies, although changes are most pronounced in the mid-thoracic region. The right and left superior facets of T1, right inferior facet of T2, right superior facet of T3, left superior and right inferior of T6, right and left superior and left inferior of T7, right and left inferior facets of T8 and T9, and the right superior and right and left inferior facets of T12 all show moderate to severe OA. In the lumbar vertebrae, the right inferior facet of L1, right superior and inferior facets of L2, right superior facet of L3, and the right inferior facet of L5 all show various amounts of osteoarthritic remodeling. Moderate osteophytosis is also present around the margins of the bodies of all of the lumbar vertebrae, and minor osteophytes are present around the margin of S1.

CATKEY: 352371 Age: 15-19 yrs. Sex: Indeterminate

There are only eight vertebrae associated with the remains of this late adolescent. These include C1 and C2, two unidentified cervical, two unidentified thoracic, and two unidentified lumbar vertebrae. Pinpoint porosities associated with OA are present on the left superior articular facet of C2, which is unusual considering the young age of this individual. No other pathologies or anomalies are present on the few remains present.

CATKEY: 352372 Age: 10-14 yrs. Sex: Indeterminate

There are 16 presacral vertebrae and a complete sacrum associated with this adolescent. All seven cervical vertebrae are present, along with T10 through T12, four unidentified thoracic, and 2 unidentified lumbar vertebrae. No pathologies or anomalies are present on these few remains from this young individual.

CATKEY: 352373 Age: 35-49 yrs. Sex: Male

The vertebral column of this middle adult male is comprised of one cervical (C7), nine thoracic (T1, T4-T7, T9-T12), and all five lumbar vertebrae. A complete sacrum is also included with these remains. No pathologies are present on the lone cervical vertebra. With the exception of T1, the thoracic vertebrae present all exhibit some degree of remodeling attributable to OA. Lipping around the margins of the articular facets, and osteophyte development are most pronounced in the mid-thoracic region. T12 also shows lumbarization, evidenced by a change of the transverse processes and superior articular facets to resemble those of a lumbar vertebra. In the lumbar segment, L1 has osteoarthritic remodeling of both the left and right inferior articular facets. L2 through L4 have all been glued together prior to this analysis, making many observations difficult. All of the lumbar vertebrae exhibit moderate to severe osteophyte development around the bodies of the vertebrae. Spondylolysis is present on L3, L4, and L5. L3 has complete separation through *pars interarticularis* on the left and only partial separation through the pedicle on the right. L4 and L5 both show complete bilateral separation through *pars interarticularis*. No pathologies are noted on the sacrum of this individual.

CATKEY: 352374 Age: 35-49 yrs. Sex: Male

This middle adult male has two unidentified cervical vertebrae, T10, T12, three unidentified thoracic vertebrae, and L3 through L5, as well as a complete sacrum. Although there is heavy taphonomic erosion, OA is apparent on all of the vertebrae present. The unidentified cervical and thoracic vertebrae exhibit pronounced deterioration of the articular facets. T10 has remodeling of both the superior and inferior facets, but the superior facets appear to be more severely affected. T12 has similar involvement of the articular facets, but there is also a small circular depression (approximately 3 mm in diameter) on the left inferior articular facet. This depression is surrounded by pinpoint porosities on the dorsal half of the facet. It is unclear what was the cause of this depression, but it is possible that a small bone fragment had lodged between this facet and the corresponding facet of L1. Unfortunately, L1 was not present for this individual. L3 through L5 were present, and all of them showed severe osteoarthritic remodeling of the superior and inferior facets. In addition, all lumbar vertebrae exhibited osteophyte development around the bodies, ranging from little expression in L5, to severe expression with curved spicules on L3. The sacrum of this individual has a partially bifurcated spinous process of S1. It does not appear that this condition is related to *spina bifida occulta*, but more likely it is related to attachment of the *iliocostalis lumborum* or *longissimus thoracis*, both part of the *erector spinae*, with origins along the medial and lateral sacral crests. Finally, a single lumbar vertebra that appears to be a fifth lumbar from a different individual is included with these remains. This single vertebra exhibits bilateral spondylolysis through *pars interarticularis*, but since it does not belong with this individual it was not included in the overall analysis.

CATKEY: 352375 Age: 20-34 yrs. Sex: Male

There are 15 presacral vertebrae and a fragmentary sacrum associated with this young adult male. These include one unidentified cervical and four unidentified lumbar vertebrae, along with T1 through T10. There is no evidence for OA in any of the vertebral elements, although moderate taphonomic erosion has taken place, making some observations difficult. It appears that some syndesmophyte development was present along the lateral margins of some of the thoracic vertebrae. The sacrum is too fragmented and weathered to make observations possible.

CATKEY: 352376 Age: 35-49 yrs. Sex: Male

There are only four presacral vertebrae from this middle adult male. They are comprised of three unidentified thoracic and one unidentified lumbar vertebrae. A complete sacrum is also present. The thoracic vertebrae show some syndesmophyte development along the lateral margin of the body, but no OA is present on any of the vertebrae. There are no anomalies or pathologies noted for the sacrum.

CATKEY: 352377 Age: 35-49 yrs. Sex: Female

This middle adult female includes a complete 24 element presacral vertebral column, and sacrum. Osteoarthritic remodeling is present throughout the entire column. The cervical vertebrae all exhibit porosities of the articular facets and moderate to extreme osteophytosis around the vertebral bodies. There are numerous changes noted throughout the thoracic region of this individual. OA is present on nearly every articular facet of the thoracic vertebrae, and on the costal facets of the bodies of T4 through T12. T6 exhibits a "tear drop" shaped fossa on both laminae. Both are well defined with smooth edges, giving the impression that the crests of the spinous processes were partially bifurcated. T7 appears to have been similarly affected, with faint evidence of teardrop shaped margins, but the fossa development is not present. T8 through L5 all exhibit bilateral thinning of the laminae. The etiology of this condition is not clear, and no other individuals exhibited anything similar to it in this collection. Like the cervical and thoracic vertebrae, the lumbar vertebrae all exhibited osteoarthritic remodeling of the articular facets. L1 has a Schmorl's node on the left side of the superior surface of the body, and another minor depression on the right side of the superior body that may be an incipient herniation. L1 also exhibits single endplate depression of the vertebral body with wedging sloping anteriorly and to the right. Complete bilateral spondylolysis through *pars interarticularis* is present on L4. Osteophyte development in the lumbar vertebrae ranges from moderate on L1 to none on L3 to severe on both the superior and inferior margins of the body of L5. Severe osteophyte development is also present around the margin of the first sacral element, such that there is some bone to bone contact between the bodies of L5 and S1 along the right lateral anterior margin. Partial lumbarization has taken place, with separation of the body of S1 from S2 and remodeling of the ala of S1 to resemble lumbar transverse processes. There is also a fracture through the ventral surface of the body of S4. It appears that some healing had taken place prior to death, but there was not a great deal of bone remodeling. Finally, there is apparent ossification of the anterior sacro-iliac ligament attaching S1 on the lateral anterior margins to S2. It is possible that this ossification was related to the lumbarization of S1 combined with the severe osteoarthritis present throughout the vertebral column.

CATKEY: 352378 Age: 35-49 yrs. Sex: Female

There are 22 presacral vertebrae, missing only L2 and L5, and a complete sacrum associated with this middle adult female. Most of the vertebral bodies exhibit considerable amounts of erosion due to weathering, however observations of the articular facets are still possible. Osteoarthritic remodeling is evident on the right superior facet, left inferior facet, and odontoid process of C2, and the left superior facet of C3. OA involvement in the thoracic vertebrae is discontinuous, with OA present on the right inferior facets of T2 and T3, right superior facets of T4, T6, and T12, left superior facets of T8 and T11, and the left inferior facet of T10. In the lumbar segment, both L3 and L4 exhibit osteoarthritic remodeling. L3 shows changes to all four articular facets, whereas L4 exhibits remodeling of the superior facets only. No pathologies or anomalies are noted on the sacrum.

CATKEY: 352379A Age: 35-49 yrs. Sex: Female

This middle adult female includes only two vertebrae, C2 and C3, which are fused at the articular facets and laminae. Osteoarthritis is present on the odontoid process of C2 and the inferior articular surfaces of C3, but it is not severe and is more likely a result of the block vertebrae rather than the cause. The condition observed here is most likely Klippel-Feil syndrome, characterized by any type of segmentation failure in the developing cervical spine (Spillane et al., 1957).

CATKEY: 352380 Age: 35-49 yrs. Sex: Female

The fragmentary remains of this middle adult female include only one unidentified cervical, five unidentified thoracic, and three unidentified lumbar vertebrae. No pathologies are noted in the single cervical vertebra present, but single endplate wedging is present in one of the unidentified mid-thoracic vertebrae. Two of the lumbar vertebrae also show wedging. One exhibits extreme concavity of the inferior body and single end plate wedging of the superior body, while the other has extreme biconcavity without wedging. It appears that all of the wedging and collapse of the vertebral bodies is due to bone thinning associated with osteoporosis, but because of both the fragmentary nature of these remains and the weathering, it is difficult to assess the extent of these changes throughout other elements of the postcrania.

CATKEY: 352381 Age: 20-34 yrs. Sex: Female

There are 22 presacral vertebrae and a complete sacrum associated with this young adult female. The cervical region includes C1, C2 and two unidentified cervical vertebrae. The remaining vertebral column is complete. No pathologies or anomalies are noted for any of the vertebrae or the sacrum of this individual.

CATKEY: 352382 Age: 35-49 yrs. Sex: Female

The first cervical vertebra is the only element missing from the column of this middle adult female. A complete sacrum is also included with these remains. In the cervical region, the odontoid process of C2, and the right and left superior facets of C3 all exhibit osteoarthritic remodeling. C2 through C5 also all show extreme osteophyte development around the vertebral bodies. It appears that C3 and C4 may have been fused, but have broken apart postdepositionally. In the thoracic vertebrae, T1 shows remodeling of the right and left superior facets and the costal facets on the body. T4 exhibits a small amount of OA on the right inferior facet. Similarly, T9 has a small amount of remodeling on the left superior facet, but it also exhibits a greater degree of osteoarthritic change in the inferior facets. OA is present on all four articular facets of T10. T11 has surface remodeling of the left superior facet, and T12 has OA involvement of both the right and left inferior facets. In the lumbar vertebrae, all except L5 show OA on the articular facets. All four articular facets of L1 are remodeled, while on L2 only the right inferior facet shows any change. The right and left inferior facets of L3 and the right and left superior facets of L4 also exhibit osteoarthritic remodeling. Osteophyte development around the margins of the vertebral bodies of L4 and L5 is moderate. A single Schmorl's node is present on L1 in the form of a slight depression on the dorsal aspect of the inferior body. It does not penetrate the outer table of bone. On the sacrum, the only change noted is the presence of moderate osteophytes around the right ventral margin of the body of S1.

CATKEY: 352382 Age: 35-49 yrs. Sex: Female

A complete 24 element presacral vertebral column and a partial sacrum are included with the remains of this middle adult female. Although the remains are badly weathered, observations of pathologies are possible for nearly all elements present. Much of the weathering was aggravated by the very thin bones, due to osteoporosis, in this individual. In the cervical region, the articulation with the odontoid process on C1, as well as the odontoid process itself on C2 both exhibit moderate remodeling due to OA. C2 also shows remodeling of the left superior facet and the right and left inferior facets. C3 through C5 all exhibit remodeling of the left superior and inferior articular facets. C6 shows osteoarthritic change of the left superior facet, and C7 on the right inferior facet. In the thoracic region remodeling due to OA is present on all four articular facets of T6, the left and right inferior facets of T7 and T8, the right and left superior facets of T9 and T10, the left inferior facet of T10, right and left inferior facets of T11, and all four articular facets of T12. Schmorl's nodes are present on the superior bodies of T8 and T12, and the inferior body of T10. Single endplate depression with wedging is present on T8 and T12, presumably associated with the intervertebral disk herniations on the superior bodies of each. In the lumbar region, all four articular facets of L1 through L3, and L5 exhibit osteoarthritic remodeling. On L4 only the right and left inferior facets are affected. Schmorl's nodes are present on the superior bodies of L1, L2, L3, and L5. Single endplate depression with wedging is also present on L1. No pathologies were noted on the badly weathered sacrum.

CATKEY: 352386   Age: 35-49 yrs.   Sex: Male

The vertebral remains of this middle adult male include only one unidentified mid-thoracic vertebra and one unidentified lumbar vertebra. A complete sacrum accompanies these two vertebrae. Syndesmophytes are present on the superior aspect of the vertebral arches of both vertebrae and osteophyte development around the body of the lumbar vertebra is moderate. The complete sacrum has six elements, including a partially fused first coccygeal. Cc1 is fused on only the right lateral aspect. No other pathologies or anomalies are noted.

CATKEY: 352387A   Age: 20-34 yrs.   Sex: Female

A complete 24 element presacral vertebral column and complete sacrum are included with the remains of this young adult female. Moderate osteoarthritic remodeling is present on the right and left superior facets of C1. Remodeling, in the form of small depressions, is present on the right and left superior facets of C3 and C4. There is one anomaly present in the thoracic vertebrae. T1 has a completely separated neural arch. Unfortunately, no photographs were taken of this condition, which has no known correlates in the literature. The sacrum exhibits a partial fracture through the left ala, with some healing present, although it was incomplete at the time of death. There was no associated pathology with the corresponding innominate.

CATKEY: 352387B Age: Unknown Sex: Indeterminate

This individual is represented by only a single, badly weathered, unidentified thoracic vertebra. No observations for pathologies or anomalies are possible.

CATKEY: 352388 Age: 20-34 yrs. Sex: Female

The remains of this young adult female include a nearly complete presacral vertebral column, missing only L2. A complete sacrum is also included. In the cervical vertebrae OA is present on the odontoid process of C2 and the right superior articular facet of C3. In the thoracic segment, only T11 shows osteoarthritic remodeling. All four articular facets of T11 exhibit slight to moderate OA. The only pathology associated with the lumbar vertebrae is complete bilateral spondylolysis through *pars interarticularis* of L4. There are pseudarthroses at the fracture location on both sides. The sacrum exhibits partial lumbarization of S1, in the form of a slight separation of the body of S1 from S2.

CATKEY: 352389 Age: 20-34 yrs. Sex: Male

The remains of this young adult male include C1, C2, one unidentified cervical, four unidentified thoracic, and two unidentified lumbar vertebrae. A complete sacrum is also included. Osteoarthritic remodeling of the articulation for the odontoid process on C1 includes lipping and osteophytosis, expanding the size of the articulation, and polish eburnation of most of the original articular surface. The odontoid process of C2 is also affected by OA. Like C1, changes include lipping, osteophytosis, and polish eburnation of the articular facet. C2 also exhibits remodeling of the left superior facet. The four thoracic and two lumbar vertebrae present all exhibit osteoarthritic remodeling of the articular facets. Osteophyte development on the thoracic and lumbar vertebrae ranges from moderate to extreme, increasing in severity caudally. Osteophytes are also present around the margins of the body of S1.

CATKEY: 352390 Age: 20-34 yrs. Sex: Female

Twenty-one presacral vertebrae and a complete sacrum are included in the remains of this young adult female. The only vertebrae missing are C4, T2, and L2. In the cervical vertebrae OA is present on the right superior and left inferior articular facets, as well as the articulation for the odontoid process on C1. The odontoid process and the left superior and inferior facets of C2, and the left superior and right and left inferior facets of C3 also exhibit moderate osteoarthritic remodeling. Some vertebral osteophyte development is also present around the margins of the bodies of C5, C6, and C7. In the thoracic region, OA is present on the costal facets of the body of T1, the right and left costal facets of the transverse processes of T5, the right costal facets of the transverse processes of T6, and T7, and the left and right costal facets of the transverse processes of T8. Osteophyte and syndesmophyte development are also present in the thoracic vertebrae, ranging from mild to moderate, increasing in severity caudally. OA is present on the right inferior and right superior articular facets of L4 and L5 respectively. Vertebral osteophytes are also present around the margins of the bodies of the lumbar vertebrae, increasing in severity caudally. Complete bilateral spondylolysis through *pars interarticularis* is present on L4 and L5. Spondylolisthesis is also present in the form of a ventral shift of L5 in relation to the top of the sacrum.

CATKEY: 352391 Age: 20-34 yrs. Sex: Female

Only nine vertebrae, including three unidentified cervical, three unidentified thoracic, and three unidentified lumbar, and a fragmentary sacrum accompany the badly weathered remains of this young adult female. Because of the extremely poor preservation, no observations of pathologies and anomalies are possible.

CATKEY: 352392 Age: 10-14 yrs. Sex: Indeterminate

There are no vertebrae and only a partial sacrum included with the remains of this adolescent. Because of the fragmentary nature of the remains, no observations on pathologies or anomalies are possible.

CATKEY: 352393 Age: 15-19 yrs. Sex: Probable male

There are 16 presacral vertebrae and a complete sacrum included with the remains of this late adolescent. No cervical vertebrae are included however, T1 through T0 and T12 through L5 are present. No pathologies or anomalies are noted for any of the presacral vertebrae present. The sacrum exhibits partial *spina bifida occulta* in the form of non-fusion of the laminae of both the fourth and fifth sacral elements. It appears that this is not simply an extended sacral hiatus, but rather a non-fusion of these elements, based on the appearance of partial laminae for both elements.

CATKEY: 352394 Age: 35-49 yrs. Sex: Male

The presacral vertebral column of this middle adult male is missing only C3, C4, T11, and L2. A complete sacrum is also included with these remains. There is extensive osteoarthritic remodeling throughout the vertebral column. C1 shows remodeling of both the right and left inferior facets, with eburnation polish on both. All four articular facets of C2 exhibit moderate OA. The right and left superior facets and right inferior facet of C5, right superior facet of C6, and the right superior and right and left inferior facets of C7 all show some degree of remodeling by OA. Osteophyte development in the cervical vertebrae is limited to C5 through C7 and decreases in severity caudally. Nearly all of the articular facets of the thoracic vertebrae present show moderate to severe remodeling. The costal facets of the transverse processes are involved on T1 through T3. Severe single end-plate depression with wedging is present on T8, indicating kyphosis at this location. Mild wedging is also present on T12. A single Schmorl's node is present on the inferior surface of the body of T10. Vertebral osteophytosis increases caudally throughout the thoracic region, ranging in expression from barely discernible to severe with curved spicules. In the lumbar vertebrae, the left and right superior facets of L1, left and right superior and inferior facets of L3 and L4, and the left and right superior facets of L5 all show moderate to severe osteoarthritic remodeling. Vertebral osteophyte development around the margins of the lumbar vertebral bodies is severe throughout the segment. Complete bilateral spondylolysis through *pars interarticularis* is present on L5, and the separated neural arch is missing. Osteophyte development is present around the margin of the body of S1. The sacrum also exhibits complete *spina bifida occulta*.

CATKEY: 352395 Age: 20-34 yrs. Sex: Male

Only seven presacral vertebrae, including two unidentified thoracic, T10, T11, T12, and L2, and a complete sacrum are included with the remains of this young adult male. Other than very mild osteophyte development around the margins of the bodies of the thoracic vertebrae, there were no pathologies or anomalies observed in this individual. It is interesting to note that a systemic treponemal infection is believed to have been present in this individual, based on focal lyses throughout much of the apendicular skeleton and the cranium, however there is no evidence of this infection in the vertebrae present.

CATKEY: 352396 Age: 20-34 yrs. Sex: Female

The remains of this young adult female include 20 presacral vertebrae and no sacrum, and despite the young age of this individual at the time of death there is a considerable amount of osteoarthritic remodeling throughout the vertebral column. All seven cervical vertebrae are present. OA is observed on the right superior and right and left inferior facets of C1, the right superior facet of C2, right superior and inferior facets of C3, and the left superior facet of C4. Among the thoracic vertebrae, only T1 is missing. OA is present on the right superior articular facets of T3 through T6. Vertebral osteophytes are also present around the margins of the bodies of T5 to T12, ranging from barely discernible to moderate, increasing in severity caudally. T11 exhibits a single Schmorl's node on the superior aspect of the body and single end-plate depression with wedging. T12 appears to be lumbarized, based on changes of the superior articular facets to resemble a lumbar vertebra and incipient mamillary processes. In the lumbar segment, only L2 and one unidentified lumbar vertebra (most likely L4) are present. L2 exhibits

OA on all four articular facets. The single unidentified lumbar has complete bilateral spondylolysis through *pars interarticularis.*

CATKEY: 352397 Age: Indeterminate Sex: Female

A complete 24 element presacral vertebral column and a fragmentary sacrum accompany the remains of this female. Although the remains are generally very weathered, most observations for pathologies in the presacral vertebrae were possible. The cervical vertebrae exhibited OA on the articulation for the odontoid process and all four articular facets of C1, the odontoid process, right and left superior articulations, and the left inferior facet of C2, the left superior and right inferior facets of C3, the right superior facet of C4, and the right superior and inferior facets of C7. The right superior facet of T1, left inferior facet of T6, left superior facet and right and left inferior facets of T7, and all four articular facets of T8 through T12 all show osteoarthritic remodeling. In the lumbar segment, the right and left superior facets of L1 show OA. L5 has an accessory facet on the left transverse process that articulates with an accessory facet on the left ala of S1. Because of the fragmentary and eroded condition of the sacrum, no other observation are possible.

CATKEY: 352399 Age: 20-34 yrs. Sex: Male

This young adult male includes only a fragmentary C2, six unidentified lumbar vertebrae, and a partial sacrum. No pathologies or anomalies are observed for the fragmentary presacral vertebrae. The sacrum exhibits accessory facets on the right and left laterodorsal aspects of S1, and the promontory appears to be lower than the surround surface. Unfortunately the adjoining vertebra is not present. No other observations are possible.

CATKEY: 352400 Age: 35-49 yrs. Sex: Male

The remains of this middle adult male include a nearly complete presacral vertebral column, missing only L2, but no sacrum is present. Osteoarthritic remodeling is present on the left and right inferior facets of C1, right inferior facet of C2, right superior and inferior facets of C3, right superior facet of C4, and right and left inferior facets of C7. OA is present throughout the entire thoracic region, with remodeling of nearly every articular facet, as well as the costal facets on the transverse processes of T6, T8, and T9. All superior and inferior facets of the lumbar vertebrae exhibit osteoarthritic remodeling, with the exception of the left inferior facet of L3, which appears to have been lost postmortem.

CATKEY: 352401 Age: 35-49 yrs. Sex: Female

There are 18 presacral vertebrae and a complete sacrum included with the remains of this middle adult female. Only two cervical vertebrae are present, including C2 and C4. OA is present on both, with remodeling of the odontoid process and inferior body surface of C2, and the inferior and superior body of C4. T1 is the only thoracic vertebra missing from the column. OA is present on the superior and inferior bodies of all of the thoracic vertebrae present. The right superior articular facet of T9, left superior facet of T10, right and left inferior facets of T11, and right and left superior and right inferior facets of T12 also all exhibit osteoarthritic remodeling. In addition, the right and left costal facets on the bodies of T2, T9 through T12, and the costal facets on the transverse processes of T4 and T10 are all affected by OA. In the lumbar segment, OA of the vertebral bodies is present in all elements. Furthermore, the right and left superior articular facets of L1, and all four articular facets of L4 show marked osteoarthritic changes. Complete bilateral spondylolysis through *pars interarticularis* is present on L4, with the development of a pseudarthrosis at the separation. L5 appears to have a healed fracture of the spinous process, resulting in a broad flat appearance. The sacrum has OA of both the left and right articulations with the innominate, as well as on the superior surface of the body of S1.

CATKEY: 352402 Age: 5-9 yrs. Sex: Ambiguous subadult

The remains of this child include only C1, C2, two unidentified cervical, and six fragmentary unidentified thoracic vertebrae. No pathologies or anomalies are observed in the very fragmentary remains of this young individual.

CATKEY: 352403 Age: 50+ yrs. Sex: Female

This old adult female includes a complete 24 element presacral vertebral column and sacrum. Nearly all of the vertebrae have been affected by OA. C1 and C2 show extensive remodeling. The right and left inferior articular facets of C1 exhibit porosities, lipping, and some eburnation near the lateral margins of both facets. Along the inferior margin of the articulation with the odontoid process is a large bony spur, measuring 9 mm in length, extending toward C2 and actually articulating with the odontoid process. C2 exhibits severe OA of all four articular facets, with polish eburnation on both superior facets and the left inferior facet. Osteophyte development is present on the superior aspect of the odontoid process. OA is also present on all four articular facets of C3, the right and left superior facets of C4, and the right superior facets of both C5 and C6. Severe osteophyte development is present around the margins of the bodies of C3 through C7. In the thoracic vertebrae, the right and left inferior facets of T1, left superior facet of T2, left inferior facet of T3, right and left inferior facets of T7, all four facets of T8 and T9, the right and left superior facets of T10, left superior facet and right and left inferior facets of T11, and the right superior facet of T12, although taphonomic erosion of the left superior facet of T12 makes observation impossible. The costal facets of the transverse processes show remodeling in T1, T4, T9, and T10. Osteophyte development increases from T1, beginning with barely discernible porosities, through T12, with curved spicules around the margins of the body. T12 also exhibits significant anterior wedging. OA is present on all four articular facets of L1, L3, and L4. L2 exhibits remodeling of the left superior facet and the right pedicle surface, associated with a spondylolytic separation at the pedicle on that side. The separation on the left side of the neural arch of L2 is through *pars interarticularis*. Complete unilateral spondylolysis through the right *pars interarticularis* of L4 is present. L5 exhibits OA on the right and left superior articular facets, as well as complete bilateral spondylolysis through *pars interarticularis*. A minor pseudarthrosis has formed at the point of separation of the neural arch of L5. There is some bone on bone contact also evident between the right mamillary process of L5 and the posterior border of the ala of S1. Single end-plate depression with wedging is present primarily on the right anterior body of L1. The sacrum has severe osteophytosis on the superior margin of S1. The medial sacral crest has also failed to fuse completely, resulting in partial *spina bifida occulta*.

CATKEY: 352404 Age: 20-34 yrs. Sex: Female

A complete 24 element presacral vertebral column, but no sacrum, is included with the remains of this young adult female. Taphonomic erosion of the bodies of many vertebrae makes many observations difficult, however, it appears that very few pathologies were present. There is some osteoarthritic lipping present around the articulation for the odontoid process on C1, and corresponding remodeling on the dens itself on C2. The only other OA present is located on the costal facets of the transverse processes of T9. In the lumbar vertebrae, complete bilateral spondylolysis through *pars interarticularis* of L5 is present.

CATKEY: 352405 Age: 35-49 yrs. Sex: Male

The only vertebrae included with the remains of this middle adult male are L1, L2, L3, and L5. A complete sacrum is also present. There is a significant amount of taphonomic erosion present on the bodies of all the vertebrae, but OA is observable around the margins of the bodies and on the articular facets throughout. No pathologies or anomalies are observed on the sacrum.

CATKEY: 352407 Age: 35-49 yrs. Sex: Female

Only seven vertebrae and a fragmentary sacrum are included with this middle adult female. One unidentified thoracic vertebra, T10, T11, L2, L3, and L4 are all present. No pathologies or anomalies are observed on these few vertebrae from this individual.

CATKEY: 352408 Age: 35-49 yrs. Sex: Female

There are 14 presacral vertebrae and a complete sacrum in the remains of this middle adult female. The vertebrae present include C1 through C6, three unidentified thoracic vertebrae, and all five lumbar vertebrae. OA is present on the articular facet for the odontoid process of C1, and the odontoid process itself on C2. C4 also exhibits remodeling of the right superior articular facet. No pathologies are noted for the three thoracic vertebrae. In the lumbar segment, L5 exhibits extreme osteophyte development around the margin of the body. L4 and L5 also both have complete bilateral spondylolysis through *pars interarticularis*. The sacrum has partial lumbarization of S1, as well as fusion and sacralization of the first coccygeal element.

CATKEY: 352409 Age: 1-4 yrs. Sex: Ambiguous subadult

The remains of this young child include a nearly complete vertebral column, missing only C1. The neural arches of all vertebrae present are complete, but they are not fused to the vertebral bodies. No sacrum is included with these remains. No pathologies or anomalies are present in the vertebral remains of this individual.

CATKEY: 352410 Age: 1-4 yrs. Sex: Ambiguous subadult

The remains of this young child include neural arches only from three unidentified cervical, four unidentified thoracic, and 1 unidentified lumbar vertebrae. No pathologies or anomalies are noted for these few fragmentary remains.

CATKEY: 352411 Age: Newborn - .9 yrs. Sex: Ambiguous subadult

There are neural arches for C1 and C2, ten unidentified thoracic, and two unidentified lumbar vertebrae, along with bodies for two unidentified cervical and three unidentified thoracic vertebrae. Only four of the neural arches have fused, the rest consist of unfused halves. No pathologies are noted on the remains of this very young child.

CATKEY: 352412 Age: Newborn - .9 yrs. Sex: Ambiguous subadult
Only one partially fused thoracic neural arch and portions of two others are included with the remains of this child. No pathologies are present in these fragmentary remains.

CATKEY: 352413 Age: 1-4 yrs. Sex: Ambiguous subadult
The remains of this child include a fragmentary C1, one unidentified cervical vertebra, six unidentified thoracic vertebrae, one neural arch from an unidentified lumbar vertebra, and a complete sacrum. The neural arches of the thoracic vertebrae are not fused to the bodies. No pathologies are noted for any of these remains.

CATKEY: 352414 Age: 20-34 yrs. Sex: Male
Five non-sequential thoracic vertebrae (two upper and three lower), an unidentified lumbar vertebra, and a fragmentary sacrum are included with the remains of this young adult male. Heavy postdepositional erosion is evident on the vertebrae, but some observations are possible. The thoracic vertebrae appear to have minor indications of porosities around the margins of some of the articular facets, indicating OA. One of the lower thoracic vertebrae has a Schmorl's node on the superior body measuring 3 mm by 5 mm, and penetrating the outer table of bone. The single lumbar vertebra also exhibits Schmorl's nodes, one on each side of the inferior body, but these do not penetrate the outer table of bone. The sacrum exhibits some osteophyte development around the posterior margin of the body of S1, but other observations are not possible.

CATKEY: 352416A Age: Unknown Adult Sex: Indeterminate
T1, T10, T11, six unidentified thoracic vertebrae, and one unidentified lumbar vertebrae were the only remains present for this individual, making age and sex determinations difficult. All vertebrae exhibited moderate to severe weathering. Osteoarthritic

remodeling was observable on the right superior and inferior articular facets of T1, and the superior and inferior facets of T10 and T11. No other observations were possible.

CATKEY: 352416C Age: Unknown Adult Sex: Probable female

A fragmentary sacrum is all that remains of this individual. No pathologies or anomalies are observed.

Table B1. Inventory of cervical vertebrae and spinal pathologies in the Golovin Bay collection.

Catno	Sex	Age	C1	OA	C2	OA	SN	C3	OA	SN	C4	OA	SN	C5	OA	SN	C6	OA	SN	C7	OA	SN	UIC	#C
279209	1	8	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	.	.	0	7
279210	2	9	1	.	1	X	.	1	.	.	1	.	.	1	.	.	1	.		0	.	.	0	6
333453	1	8	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
333454	1	8	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	X	.	0	7
342420	2	7	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
342421	2	7	1	.	1	.	.	1	.	.	0	.	.	0	.	.	0	.		0	.	.	0	3
346001	2	8	1	.	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	X	.	0	7
346004	2	8	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	X	.	0	7
346006	2	7	0	.	0	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	5
346007	5	6	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	1	1
346008	2	8	1	X	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	1
346009	3	5	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	0
346010	2	7	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346011	1	7	1	.	1	X	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346012	1	8	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	X	.	0	7
346013 A	2	8	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	.		1	.	.	0	7
346014	1	9	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	X	.	0	7
346015	1	7	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346016	2	8	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		1	.	.	0	1
346018	1	8	1	X	1	X	.	1	X	.	0	.	.	0	.	.	1	X		1	X	.	0	5
346019	1	8	1	.	1	X	.	1	X	.	1	X	.	1	.	.	1	.		1	.	.	0	7
346020	3	6	1	.	1	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	2	4
346021	1	8	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346022 A	2	7	1	X	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346025	3	4	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	0
346026	3	3	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	2	2
346028	2	9	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		1	.	.	1	2
346029	2	9	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	X	.	0	7
346030 A	3	4	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		1	.	.	0	1
346031	3	4	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346033	4	6	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		0	.	.	0	6
346035	3	5	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346108	2	8	1	X	1	X	.	1	.	.	1	.	.	1	.	.	1	.		0	.	.	0	6
346109	3	5	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7
346110	2	7	1	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		1	.	.	0	2
346112	3	6	1	.	1	.	.	1	.	.	1	.	.	1	.	.	0	.		0	.	.	0	5
346113 A	1	8	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	0
346114	5	6	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	0
346117 A	1	7	1	X	1	X	.	1	X	.	1	X	.	1	X	.	1	X		1	.	.	0	7
346131	6	11	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	0
352353	2	7	1	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	2	3
352359	2	7	0	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	0	0
352369	1	7	1	.	1	.	.	1	X	.	1	X	.	1	.	.	1	X		0	.	.	0	6
352370 A	2	8	1	.	1	.	.	1	.	.	1	X	.	0	.	.	1	X		1	X	.	0	6
352371	3	6	1	.	1	X	.	0	.	.	0	.	.	0	.	.	0	.		0	.	.	2	4
352372	3	5	1	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.		1	.	.	0	7

Table B1. Inventory of cervical vertebrae and spinal pathologies in the Golovin Bay collection continued.

Catno	Sex	Age	C1	OA	C2	OA	SN	C3	OA	SN	C4	OA	SN	C5	OA	SN	C6	OA	SN	C7	OA	SN	UIC	#C
352373	1	8	0	-	0	-	-	0	-	-	0	-		0	-	-	0	-	-	1	-	-	0	1
352374	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	2	2
352375	1	7	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	1
352376	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352377	2	8	1	X	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	0	7
352378	2	8	1	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
352379 A	2	8	0	-	1	X	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
352380	2	8	0	-	0		-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	1
352381	2	7	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	2	4
352382	2	8	0	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	-	-	0	6
352384	2	8	1	X	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	0	7
352368	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352387 A	2	7	1	X	1	-	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	0	7
352387 B	6	12	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352388	2	7	1	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
352389	1	7	1	X	1	X	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	3
352390	2	7	1	X	1	X	-	1	X	-	0	-	-	1	-	-	1	-	-	1	-	-	0	6
352391	2	7	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	3	3
352393	4	6	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352394	1	8	1	X	1	X	-	0	-	-	0	-	-	1	X	-	1	X	-	1	X	-	0	5
352395	1	7	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	-	-	0	1
352396	2	7	1	X	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	0	7
352397	2	11	1	X	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	1	X	-	0	7
352399	1	7	0	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	1
352400	1	8	1	X	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	1	X	-	0	7
352401	2	8	0	-	1	X	-	0	-	-	1	X	-	0	-	-	0	-	-	0	-	-	0	2
352402	3	4	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	2	4
352403	2	9	1	X	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	0	7
352404	2	7	1	X	1	X	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
352405	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352407	2	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352408	2	8	1	X	1	X	-	1	-	-	1	X	-	1	-	-	1	-	-	0	-	-	0	6
352409	3	3	0	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	6
352410	3	3	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	3	3
352411	3	2	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	2	4
352412	3	2	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352413	3	3	1	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	2
352414	1	7	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
352416 A	6	11	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0

Sex: 1 = male, 2 = female, 3 = indeterminate, 4 = probable male 5 = probable female 6 = ambiguous
Age: 1 = fetal, 2 = newborn - 0.9 yrs, 3 = 1 - 4 yrs, 4 = 5 - 9 yrs 5 = 10 - 14 yrs, 6 = 15 - 19 yrs 7 = 20 - 34 yrs, 8 = 35 - 49 yrs, 9 = 50 +
10 = subadult, age indeterminate, 11 = adult age indeterminate, 12 = unknown
For each cervical vertebra, 1/0 denotes presence/absence
OA = osteoarthritis, SN = Schmorl's node, X = presence of condition
UIC = unidentified cervical vertebrae
#C = number of cervical vertebrae

Table B2. Inventory of thoracic vertebrae and spinal pathologies in the Golovin Bay collection.

Catno	Sex	Age	T1	OA	SN	T2	OA	SN	T3	OA	SN	T4	OA	SN	T5	OA	SN	T6	OA	SN	T7	OA	SN	T8	OA	SN	T9	OA	SN	T10	OA	SN	T11	OA	SN	T12	OA	SN	UT	#T
279209	1	8	1	X	·	1	X	·	1	·	·	1	·	·	1	X	·	1	X		1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
279210	2	9	0	·		1	X	·	1	X	·	1	X		1	X	·	1	X	·	1	X	·	1	X	·	1	X		1	X	·	1	X	·	1	X	·	0	11
333453	1	8	1	·	·	1	·	·	1	X	·	1	X	·	1	X	·	1	X	X	1	X	·	1	X	·	1	X	X	1	X	·	1		X	1		X	0	12
333454	1	8	1	X	·	1	·	·	1	X	·	1	X	·	1	X	·	1	X	·	1			1	·	·	1	X	·	1	X	·	1	·	·	1	·	·	0	12
342420	2	7	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
342421	2	7	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0	·	·	0		·	0	·	·	0	·		0	·	·	0	·	·	0	·	·	0	0
346001	2	8	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346004	2	8	1	·	·	1	·	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346006	2	7	1	·	·	1	·	·	1	·		1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·	·	1	·	·	1		·	1	·	·	0	12
346007	5	6	1	·	·	1	·	·	1		·	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·		1	·	·	0	·	·	0	·	·	0	10
346008	2	8	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	0
346009	3	5	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0	·	·	0	·	·	0	·	·	0			1	·	·	1		·	1	·	·	1	4
346010	2	7	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X		1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346011	1	7	1	X	·	1	X	·	1	·	·	1	·	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346012	1	8	1	X	·	1	X	·	1	X	·	1	X	·	1	X	X	1	X	X	1	X	X	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346013 A	2	8	1	X	·	1	·	·	1	·	·	1	X	·	1	·	·	1	X	·	1	X	·	1	X	·	1	X	·	1	·	·	1	·	·	1	X	·	0	12
346014	1	9	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346015	1	7	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1			1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
346016	2	8	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·		1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·	·	0	12
346018	1	8	1	·	·	1	·	·	1	·	·	1	X	·	1	X	·	1	X		1	X	·	1	X	·	1	X		1	X	·	1	X	·	1	X	·	0	12
346019	1	8	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	·	·	1	X	·	0	12
346020	3	6	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
346021	1	8	1	·	·	1	·	·	1		·	1	X	·	1	X	·	1	X	·	1	X		1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
346022 A	2	7	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0	12
346025	3	4	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0		·	0		·	0	·	·	0	·		0		·	0	·	·	0	·	·	5	5
346026	3	3	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0	·	·	0	·	·	0	·	·	0	·		0	·	·	0	·	·	0		·	3	3
346028	2	9	1	X	·	1	·	·	1		·	1		·	1	·	·	1	X		1	·	X	1		·	1	X	X	1	X	X	1	X	X	1	X	X	0	12
346029	2	9	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X		0		·	0	·	·	1	X	·	0	10
346030 A	3	4	0	·	·	0	·	·	0	·	·	0	·	·	0	·		0		·	0	·		0	·	·	0	·	·	0	·	·	0		·	1	·	·	1	2
346031	3	4	1	·	·	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·	·	1		·	1		·	1	·	·	1		·	1	·	·	0	12
346033	4	6	0	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·	·	1	·	·	1	·	·	0	11
346035	3	5	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
346108	2	8	0	·	·	0	·	·	0	·		0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·		0	·	·	0	·	·	0	·	·	0	0
346109	3	5	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	X	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
346110	2	7	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X		1	X	·	1	X	·	1	X	·	1	X	·	1	·	·	1	·	·	0	12
346112	3	6	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0			0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	5	5
346113 A	1	8	0	·	·	0	·	·	0	·	·	0		·	0	·	·	1	·	·	1	X	X	1	X	X	1	X	X	1	X	X	1	X	X	1	X	X	0	7
346114	5	6	0	·	·	0	·	·	0		·	0	·	·	0	·	·	0	·		0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	8	8
346117 A	1	7	1	·	·	1	·	·	1	·	·	1		·	1	·	·	1	·		1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	12
346131	6	11	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0		·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	0
352353	2	7	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	0			1	X	·	0	·	·	0	10
352359	2	7	0	·	·	0	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	1	·	·	0	10
352369	1	7	1	X	·	1	·	·	1	·	·	1	X	·	1	X	·	1	X	·	1	·	·	1	X	·	1	X		1	X		1	X	·	1	X	·	0	12
352370 A	2	8	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	X	·	1	·	·	1	·		1	X	·	0	12
352371	3	6	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0		·	0	·	·	0	·	·	0	·	·	2	2
352372	3	5	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·	·	0	·		1	·	·	1		·	1	·	·	4	7

Table B2. Inventory of thoracic vertebrae and spinal pathologies in the Golovin Bay collection continued.

Catno	Sex	Age	T1	OA	SN	T2	OA	SN	T3	OA	SN	T4	OA	SN	T5	OA	SN	T6	OA	SN	T7	OA	SN	T8	OA	SN	T9	OA	SN	T10	OA	SN	T11	OA	SN	T12	OA	SN	UTT	#T
352373	1	8	1			0			0			1	X		1	X		1	X		1	X		0			1	X		1	X		1	X		1	X		0	9
352374	1	8	0			0			0			0			0			0			0			0			0			1	X		0			1	X		3	5
352375	1	7	1			1			1			1			1			1			1			1			1			1			0			0			0	10
352376	1	8	0			0			0			0			0			0			0			0			0			0			0			0			3	3
352377	2	8	1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		0	12
352378	2	8	1			1	X		1	X		1	X		1			1	X		1			1	X		1			1	X		1	X		1	X		0	12
352379 A	2	8	0			0			0			0			0			0			0			0			0			0			0			0			0	0
352380	2	8	0			0			0			0			0			0			0			0			0			0			0			0			5	5
352381	2	7	1			1			1			1			1			1			1			1			1			1			1			1			0	12
352382	2	8	1	X		1			1			1	X		1			1			1			1			1	X		1	X		1	X		1	X		0	12
352384	2	8	1			1			1			1			1			1	X		1	X		1	X	X	1	X		1	X	X	1	X		1	X	X	0	12
352368	1	8	0			0			0			0			0			0			0			0			0			0			0			0			1	1
352387 A	2	7	1			1			1			1			1			1			1			1			1			1			1			1			0	12
352387 B	6	12	0			0			0			0			0			0			0			0			0			0			0			0			1	1
352388	2	7	1			1			1			1			1			1			1			1			1			1			1	X		1			0	12
352389	1	7	0			0			0			0			0			0			0			0			0			0			0			0			4	4
352390	2	7	1	X		0			1			1			1	X		1	X		1	X		1	X		1			1			1			1			0	11
352391	2	7	0			0			0			0			0			0			0			0			0			0			0			0			3	3
352393	4	6	1			1			1			1			1			1			1			1			1			1			1			0			0	11
352394	1	8	1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X	X	0			1	X		0	11
352395	1	7	0			0			0			0			0			0			0			0			0			1			1			1			2	5
352396	2	7	0			1			1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X	X	1	X		0	11
352397	2	11	1	X		1			1			1			1			1	X		1	X		1	X		1	X		1	X		1	X		1	X		0	12
352399	1	7	0			0			0			0			0			0			0			0			0			0			0			0			6	6
352400	1	8	1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		0	12
352401	2	8	0			1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		1	X		0	11
352402	3	4	0			0			0			0			0			0			0			0			0			0			0			0			6	6
352403	2	9	1	X		1	X		1	X		1	X		1			1			1	X		1	X		1	X		1	X		1	X		1	X		0	12
352404	2	7	1			1			1			1			1			1			1			1			1	X		1			1			1			0	12
352405	1	8	0			0			0			0			0			0			0			0			0			0			0			0			0	0
352407	2	8	0			0			0			0			0			0			0			0			0			1			1			0			1	3
352408	2	8	0			0			0			0			0			0			0			0			0			0			0			0			3	3
352409	3	3	1			1			1			1			1			1			1			1			1			1			1			1			0	12
352410	3	3	0			0			0			0			0			0			0			0			0			0			0			0			4	4
352411	3	2	0			0			0			0			0			0			0			0			0			0			0			0			10	10
352412	3	2	0			0			0			0			0			0			0			0			0			0			0			0			3	3
352413	3	3	0			0			0			0			0			0			0			0			0			0			0			0			6	6
352414	1	7	0			0			0			0			0			0			0			0			0			0			0			0			5	5
352416 A	6	11	1	X		0			0			0			0			0			0			0			0			1	X		1	X		0			6	9

Sex: 1 = male, 2 = female, 3 = indeterminate, 4 = probable male 5 = probable female 6 = ambiguous
Age: 1 = fetal 2 = newborn - 0.9 yrs 3 = 1 - 4 yrs, 4 = 5 - 9 yrs 5 = 10 - 14 yrs 6 = 15 - 19 yrs 7 = 20 - 34 yrs 8 = 35 - 49 yrs, 9 = 50 +,
10 = subadult, age indeterminate, 11 = adult age indeterminate 12 = unknown
For each thoracic vertebra, 1 0 denotes presence absence
OA = osteoarthritis, SN = Schmorl's node, X = presence of condition
UTT = unidentified thoracic vertebrae
#T = number of thoracic vertebrae

Table B3. Inventory of lumbar vertebrae and spinal pathologies in the Golovin Bay collection.

Catno	Sex	Age	L1	OA	SN	SP	L2	OA	SN	SP	L3	OA	SN	SP	L4	OA	SN	SP	L5	OA	SN	SP	UTL.	#L.
279209	1	8	0				1	X			1	X			1	X			1	X		X	0	4
279210	2	9	1				1				1				1	X		X	1	X		X	1*	6
333453	1	8	1				1				1				1				1	X		X	0	5
333454	1	8	1	X			1	X			1	X			1	X			1	X			1*	6
342420	2	7	1				1	X			1	X			1	X			1	X			0	5
342421	2	7	0				0				0				0				0				0	0
346001	2	8	1	X			1	X			1	X			1	X		X	1	X		X	0	5
346004	2	8	1	X			1	X			1	X			1	X			1	X			0	5
346006	2	7	1				1				1				1				1				0	5
346007	5	6	0				0				0				0				0				1	1
346008	2	8	0				1	X			1	X			0				0				0	2
346009	3	5	1				1				1				0				1				0	4
346010	2	7	1	X	X		1	X			1	X			1	X			1	X			0	5
346011	1	7	1	X			1	X			1				1				1				0	5
346012	1	8	1	X			0				0				0				0				1	2
346013 A	2	8	1	X			1				1				1				1				0	5
346014	1	9	1	X			1	X			1	X			1	X			1	X		X	0	5
346015	1	7	1				1				1				1				1	X		X	0	5
346016	2	8	1	X			1	X			1	X			1	X			1	X		X	0	5
346018	1	8	1	X			1	X			1	X		X	1	X		X	1	X		X	0	5
346019	1	8	1				1				1				1				1	X		X	0	5
346020	3	6	1				1				1				1				1				0	5
346021	1	8	1	X			1	X			1				1				1			X	0	5
346022 A	2	7	1			X	1				1				1				1				0	5
346025	3	4	0				0				0				0				0				4	4
346026	3	3	0				0				0				0				0				4	4
346028	2	9	1	X	X		1	X	X		1	X	X		1	X	X		1	X			0	5
346029	2	9	1	X	X		0				1	X			1	X			1	X			0	4
346030 A	3	4	1				1				0				0				1				0	3
346031	3	4	1				1				1				1				0				0	4
346033	4	6	1				1				1				1				1				0	5
346035	3	5	1				1				1				1				1				0	5
346108	2	8	0				0				0				0				0				0	0
346109	3	5	1				1				1				1				1				0	5
346110	2	7	1				1				1				1				1				0	5
346112	3	6	0				0				0				0				0				3	3
346113 A	1	8	1	X	X		1	X			1	X	X		1	X			1				0	5
346114	5	6	0				0				0				0				0				3	3
346117 A	1	7	1				1				1				1				1				0	5
346131	6	11	0				0				0				0				1	X		X	0	1
352353	2	7	0				0				0				0				0				1	1
352359	2	7	0				0				0				0				0				2	2
352369	1	7	1	X			1				1	X			1	X		X	1				0	5
352370 A	2	8	1	X			1	X			1	X			1				1	X			0	5
352371	3	6	0				0				0				0				0				2	2
352372	3	5	0				0				0				0				0				2	2

Table B3. Inventory of lumbar vertebrae and spinal pathologies in the Golovin Bay collection continued.

Catno	Sex	Age	L1	OA	SN	SP	L2	OA	SN	SP	L3	OA	SN	SP	L4	OA	SN	SP	L5	OA	SN	SP	UTL	#L
352373	1	8	1	X			1	X			1	X		X	1	X		X	1	X		X	0	5
352374	1	8	0				0				1	X			1	X			1	X			0	3
352375	1	7	0				0				0				0				0				4	4
352376	1	8	0				0				0				0				0				1	1
352377	2	8	1	X	X		1	X			1	X			1	X		X	1	X			0	5
352378	2	8	1				0				1	X			1	X			0				0	3
352379 A	2	8	0				0				0				0				0				0	0
352380	2	8	0				0				0				0				0				3	3
352381	2	7	1				1				1				1				1				0	5
352382	2	8	1	X	X		1	X			1	X			1	X			1				0	5
352384	2	8	1	X	X		1	X	X		1	X	X		1	X			1	X	X		0	5
352368	1	8	0				0				0				0				0				1	1
352387 A	2	7	1				1				1				1				1				0	5
352387 B	6	12	0				0				0				0				0				0	0
352388	2	7	1				0				1				1			X	1				0	4
352389	1	7	0				0				0				0				0				2	2
352390	2	7	1				0				1				1	X		X	1	X		X	0	4
352391	2	7	0				0				0				0				0				3	3
352393	4	6	1				1				1				1				1				0	5
352394	1	8	1	X			0				1	X			1	X			1	X		X	0	4
352395	1	7	0				1				0				0				0				0	1
352396	2	7	0				1	X			0				1			X	0				0	2
352397	2	11	1	X			1				1				1				1				0	5
352399	1	7	0				0				0				0				0				0	0
352400	1	8	1	X			0				1	X			1	X			1	X			0	4
352401	2	8	1	X			1	X			1	X			1	X		X	1	X			0	5
352402	3	4	0				0				0				0				0				0	0
352403	2	9	1	X			1	X		X	1	X			1	X	X	X	1	X		X	0	5
352404	2	7	1				1				1				1				1			X	0	5
352405	1	8	1	X			1	X			1	X			0				1	X			0	4
352407	2	8	0				1				1				1				1				0	4
352408	2	8	1				1				1				1			X	1	X		X	0	5
352409	3	3	1				1				1				1				1				0	5
352410	3	3	0				0				0				0				0				1	1
352411	3	2	0				0				0				0				0				2	2
352412	3	2	0				0				0				0				0				0	0
352413	3	3	0				0				0				0				0				1	1
352414	1	7	0				0				0				0				0				1	1
352416 A	6	11	0				0				0				0				0				1	1

Sex: 1 = male, 2 = female, 3 = indeterminate, 4 = probable male 5 = probable female 6 = ambiguous
Age: 1 = fetal, 2 = newborn - 0.9 yrs, 3 = 1 - 4 yrs, 4 = 5 - 9 yrs 5 = 10 - 14 yrs 6 = 15 - 19 yrs 7 = 20 - 34 yrs 8 = 35 - 49 yrs, 9 = 50 +,
10 = subadult, age indeterminate, 11 = adult age indeterminate 12 = unknown
For each lumbar vertebra, 1/0 denotes presence/absence
OA = osteoarthritis, SN = Schmorl's node, SP = spondylolysis, X = presence of condition
UTL = unidentified lumbar vertebrae, * includes 6th lumbar vertebra
#L = number of lumbar vertebrae

C Inventory of Individuals from Nunivak Island

CATKEY: 339103 Age: 15-19 yrs. Sex: Ambiguous subadult

There are 23 presacral vertebrae present (missing only C6) for this late adolescent. No sacrum accompanied these remains. Sexually diagnostic indicators are ambiguous, so no determination is possible. No pathologies or anomalies were observed on any of these well preserved vertebrae from this young individual.

CATKEY: 339104A Age: 15-19 yrs. Sex: Male

Like the previous individual, this late adolescent included 23 presacral vertebrae (missing only C6). A complete sacrum accompanied these remains. The epiphyses of the vertebrae were all unfused and not present. No pathologies or anomalies are noted in the presacral vertebrae. The five element sacrum had a sacral hiatus extending up through S3. The spinous process of S1 is broken off, as a result of postmortem damage, but it appears that it was incompletely fused. It also appears as if there may have been a foramen passing through S1, but it is unclear because of the breakage. Not all of the sacral elements are completely fused along both the ventral and dorsal aspects. No other anomalies of the sacrum are present.

CATKEY: 339106 Age: 35-49 yrs. Sex: Male

The remains of this middle adult male include 22 presacral vertebrae, and a complete sacrum, only L2 and L3 are missing. Osteoarthritic remodeling is present on the right inferior body of C2, right superior body of C3, and left inferior body of C4. The thoracic vertebrae exhibit vertebral osteophytosis around the margins of the bodies of T6 through T10, and T12. T11 is unobservable for pathologies because of postdepositional damage. Some OA is present around the bodies of most of the thoracic vertebrae as well. In the lumbar vertebrae, L1 and L4 both exhibit osteophyte development around the margins of the bodies, including porosities around the margins and within the endplates of L4. L5 is unobservable because of postdepositional damage. The five element sacrum included with this individual does not exhibit any pathologies or anomalies.

CATKEY: 339107 Age: 20-34 yrs. Sex: Male

The vertebrae included with the remains of this young adult male are C1, C2, C7, and one unidentified cervical vertebra, T1, T4 through T12, and all five lumbar vertebrae. A complete five element sacrum is also included. All vertebrae and the sacrum show mild to moderate weathering. No pathologies are present in the cervical vertebrae. In the thoracic vertebrae, syndesmophytes are present between the superior articular facets of T5 through T10. No pathologies appear to be present in the lumbar region. The sacrum exhibits *spina bifida occulta*, with incompletely formed spinous processes for both S1 and S2. The spinous process of S3 is only partially fused. The sacral hiatus extends up to the bottom of S3.

CATKEY: 339108 Age: 35-49 yrs. Sex: Male

Twenty presacral vertebrae and a complete sacrum are included with the remains of this middle adult male. Cervical vertebrae include C2, C3, C4, C6, and C7. In the thoracic segment only T2 and T11 are missing. All five lumbar vertebrae are present. No pathologies are noted in the cervical region. Mild osteophytes are present around the margins of the bodies of T1, and T7 through T10. OA is present on the costal facets on the body of T1, right inferior articulation of T9, right superior of T10, and right inferior of T12. More developed osteophytes, with porosities, are present around the margins of the bodies of L2, L3, and L4. L2 also exhibits complete bilateral spondylolysis through *pars interarticularis*. Osteoarthritic remodeling of the articular facets in the lumbar vertebrae is present on the right inferior facet of L2, right superior and inferior of L3, and right and left superior of L4. The complete five element sacrum exhibits complete *spina bifida occulta*.

CATKEY: 339109 Age: 35-49 yrs. Sex: Male

The remains of this middle adult male include C1, C2, T1, T5 through T12, and all five lumbar vertebrae. No sacrum accompanies these remains. Most of the vertebral bodies exhibit mild to moderate postdepositional weathering. Osteoarthritic remodeling is present on the right inferior and right superior articular facets of C1 and C2 respectively. All of the thoracic vertebrae present, with the exception of T5, which is unobservable because of weathering, show mild osteophyte development around the margins of the vertebral bodies. Syndesmophytes are also present between the superior articular facets of T6 through T10. OA is present on the left transverse process of T9, left and right inferior articulations of T11, and right superior articulation and right costal facet on the body of T12. The lumbar vertebrae exhibit OA on the left superior articulations of both L3 and L5.

CATKEY: 339131 Age: 35-49 yrs. Sex: Female

The vertebral remains of this middle adult female include only one vertebra, L1, and a nearly complete five element sacrum. No pathologies are noted on either of these two bones.

CATKEY: 339132 Age: 35-49 yrs. Sex: Female

Twenty-three presacral vertebrae, missing only C7, and a complete sacrum are included with the remains of this middle adult female. Although C1 is incomplete, there are no observable pathologies on any of the cervical vertebrae. All of the thoracic vertebrae appear to have minor osteophytosis around the margins of the vertebral bodies. Syndesmophytes are also present between the superior articular facets of T6 through T10. In the lumbar vertebrae, osteophytes are present on L2 through L5, with the greatest expression on the inferior of L2 and superior of L3. No pathologies are present on the five element sacrum.

CATKEY: 339133 Age: 20-34 yrs. Sex: Male

The remains of this young adult male include complete thoracic and lumbar segments, as well as a complete four element sacrum. No cervical vertebrae are present. No pathologies are apparent in the vertebrae, although nearly all of the vertebrae present exhibit extreme weathering. This individual also includes an L6 that has become sacralized. The four elements of the sacrum are not completely fused together, and S1 has been glued in place. Partial *spina bifida occulta* is present on the sacrum. The sacral hiatus extends up through the bottom of S3 and the spinous process of S3 did not fuse.

CATKEY: 339134A   Age: 20-34 yrs.   Sex: Female

This young adult female includes only T1 and one unidentified thoracic vertebra, and a complete six element sacrum. No pathologies are noted for either of the thoracic vertebrae. The six element sacrum includes an S1 that is only partially fused to the rest of the sacrum. The right ala of S1 is completely fused, while the left is partially fused, and there was clearly an intervertebral disc present based on the gap between the bodies of S1 and S2. Without a complete vertebral column it is impossible to tell if this is an L5 that has become sacralized, or a supernumerary vertebral element.

CATKEY: 339137   Age: 35-49 yrs.   Sex: Female

There are only ten presacral vertebrae and a complete sacrum included with the remains of this middle adult female. C1 and C2 are the only cervical vertebrae present. OA is present on the left and right inferior articular facets of C1. The thoracic vertebrae present include T9, T10, T11, and two unidentified vertebrae. Vertebral osteophytosis is present on all three identifiable thoracic vertebrae, including elevated rims and porosities around the margins of the bodies. Osteoarthritic remodeling is present on the right inferior articular facet of T10. L5 and two unidentifiable lumbar vertebrae are also present. Osteophytosis is present on all lumbar vertebrae, and L5 exhibits OA on both the right and left superior articular facets. No pathologies are observed on the complete five element sacrum.

CATKEY: 339138 Age: 50+ yrs. Sex: Male

The remains of this old adult male include C1, C2, T12, L1, and one unidentified thoracic vertebra. No pathologies are noted on the cervical vertebrae. Vertebral osteophytosis is present on both the T12 and L1. T12 also appears to be partially lumbarized with a shortening of the transverse processes and a change in the articular facets to resemble those of a lumbar vertebra.

CATKEY: 339139 Age: 35-49 yrs. Sex: Male

Only T1 is missing from the vertebral remains of this middle adult male. Syndesmophytes are present between the superior articular facets of T5, T7 through T10, and T12. T12 is also lumbarized, with superior and inferior articular facets resembling those of a lumbar vertebra. OA is present on the right and left inferior facets of T11 and superior facets of T12. No other pathologies or anomalies are present in the presacral vertebrae of this individual. The complete five element sacrum exhibits complete *spina bifida occulta*, with a completely open sacral canal.

CATKEY: 339140 Age: 35-49 yrs. Sex: Female

Twenty-one presacral vertebrae, missing C4, C7, and T2, and a complete sacrum are included with the remains of this middle adult female. Among the cervical vertebrae, OA is present on the left superior and right inferior facets of both C2 and C3, and the left and right superior articulations of C5 and C6. The thoracic vertebrae exhibit osteophytosis around the margins of the bodies of T9 through T12. T11 also has a single Schmorl's node on the superior aspect of the vertebral body. OA is present on the left and right inferior articulations of T3, left and right superior articulations of T5, and all four facets of T4, and T7 through T12. Moderate osteophyte development is present throughout the lumbar vertebrae. L5 also exhibits single endplate depression with wedging of the superior vertebral body. Osteoarthritic remodeling is present on the right inferior facet of L3, right and left superior facets of L5, and all four facets of L1, L2, and L4.

CATKEY: 339145 Age: 35-49 yrs. Sex: Male

Only four presacral vertebrae are included with the remains of this middle adult male. These include two cervical vertebrae, most likely C3 and C5, and two thoracic vertebrae, T1 and T2. Mild osteophyte development is present around the margins of the bodies of the two cervical vertebrae. OA is observable on the right inferior articulation of T1 and the right superior and left inferior facets of T2. Eburnation is present on the right inferior facet of T1 and superior facet of T2, demonstrating bone to bone contact at this articulation. Osteophytosis is present on the body of T2, but T1 is unobservable because of weathering.

CATKEY: 339146A Age: 50+ yrs. Sex: Probable Female

A single unidentified lumbar vertebra and fragmentary sacrum accompany the remains of this old adult, classified as a probable female. The lumbar vertebra exhibits considerable pathological erosion of the body, most likely associated with osteoporosis and osteoarthritis. Significant remodeling of all four articular facets on this vertebra is also present. Only the right half of the sacrum is present, and no observations are possible because of the fragmentary and weathered condition.

CATKEY: 339147 Age: 35-49 yrs. Sex: Female

A nearly complete presacral vertebral column and a complete sacrum are included with the remains of this middle adult female. The only missing vertebrae are C1 through C4. No pathologies or anomalies are noted in the cervical vertebrae. In the thoracic region T5 through T9 exhibit mild syndesmophyte development between the superior articular facets. Slight osteophyte development is present around the margins of the bodies of L4 and L5. L3 exhibits mild wedging of the vertebral body. The cause of the condition is unknown as there is no evidence of trauma, osteoporosis, or OA on this bone. The sacrum contains six elements and exhibits partial *spina bifida occulta*. The neural arches of S1 and S2 are both unfused. The sacral hiatus extends only up through S5 and the neural canal is closed over S3 and S4.

CATKEY: 339148A Age: 15-19 yrs. Sex: Probable Female

A complete 24 element presacral vertebral column and sacrum are included with the remains of this late adolescent probable female. The epiphyses of the vertebrae were unfused and most were present with the remains. OA is present on the right superior, and right and left inferior articulations of C2. Remodeling is most pronounced on the right superior articulation, including extensive erosion covering two-thirds of the facet. The right and left superior facets of C3 and left superior facet of C5 also exhibit minor porosities associated with OA. The presence of OA in the cervical vertebrae of this individual is puzzling because of the young age and lack of evidence of trauma. No other pathologies or anomalies are present in the presacral vertebrae. The five element sacrum exhibits partial *spina bifida occulta*, with incomplete fusion of the neural arch of S1. The sacral hiatus extends up through S4.

CATKEY: 339152 Age: 1-4 yrs. Sex: Indeterminate

C1 and C2 are included with the cranium of this young child. No pathologies or anomalies are noted on these few remains.

CATKEY: 339153 Age: 10-14 yrs. Sex: Indeterminate

C1 and C2 are included with the cranium of this subadult. No pathologies or anomalies are noted on these few remains.

CATKEY: 339154 Age: 35-49 yrs. Sex: Female

Twenty-one presacral vertebrae and a complete five element sacrum are included with the remains of this middle adult female. Missing vertebrae include C1, C2, and T1. The cervical vertebrae exhibit osteoarthritic remodeling on the left superior and left and right inferior articulations of C3, left and right superior facets of C4, left inferior facet of C5, and the left superior facet of C6. In the thoracic vertebrae, most of the OA is limited to the costal facets of the transverse processes of T2 through T9. Minor osteophyte development is present on T4 through T12, increasing in severity caudally. In the lumbar region, OA remodeling is present on the left and right inferior articulations of L1 and L2, all four articular facets of L3 and L4, and the left and right superior facets of L5. Eburnation and severe erosion is present between the inferior facets of L4 and the superior facets of L5. Osteophytic development is present around the margins of the bodies of all of the lumbar vertebrae. Minor spondylolisthesis is present on L4 with a slight ventral shift in relation to the position of L5. No pathologies or anomalies are present on the sacrum.

CATKEY: 339156A Age: 35-49 yrs. Sex: Female

The remains of this middle adult female include a complete 24 element presacral vertebral column and five element sacrum. No pathologies or anomalies are present in the cervical vertebrae. OA is present on the costal facets of the transverse processes of T8 through T10 in the thoracic vertebrae. The lumbar vertebrae exhibit osteoarthritic remodeling of the right and left inferior articular facets of L3, and all four facets of L4 and L5. L3 also has a Schmorl's node near the center of the superior aspect of the body, although it does not penetrate the outer table of bone. The five element sacrum exhibits partial *spina bifida occulta* in the form of an open neural canal of S1. The sacral hiatus only extend up through three-quarters of S4.

CATKEY: 339157 Age: 35-49 yrs. Sex: Female

There are 22 presacral vertebrae and complete six element sacrum included with this middle adult female. The missing vertebrae are C1 and C2. The only pathology noted in the cervical vertebrae is minor OA of the left inferior facet of C4. The thoracic vertebrae show extensive OA through the segment. The left and right inferior articulations of T3 and all four articular facets of T4 through T9 exhibit OA with erosion. The left and right inferior articulations of T10 and T11 also show osteoarthritic remodeling, including lipping and erosion of the surfaces of the facets. The costal facets on the right transverse processes of T4 through T7 also exhibit lipping and porosities associated with OA. In the lumbar segment, there is minor remodeling of the superior articular facets of L1, minor erosion of the left superior facet of L2, lipping with eburnation and erosion of both the right inferior and left superior facets of L2 and L3 respectively. Additionally, the right and left inferior articulations of L5 exhibit porosities, lipping and erosion of the joint surfaces. Minor vertebral osteophytosis is also present throughout the entire lumbar segment. The six element sacrum includes a fused first coccygeal element. The first sacral element shows OA on the right and left superior articulations. The body of S1 also has a saddle-shaped appearance, the cause of which is unknown.

CATKEY: 339158 Age: 20-34 yrs. Sex: Male

The remains of this young adult male include a complete 24 element vertebral column and five element sacrum. Minor lipping is present on the right and left inferior facets of L1, all four facets of L2, and right superior and left inferior facets of L5. The only other pathology present appears to be very minor syndesmophyte development between the superior articular facets of T10. No other pathologies or anomalies are present.

CATKEY: 339159 Age: 35-49 yrs. Sex: Female

A complete 24 element vertebral column and five element sacrum accompany the remains of this middle adult female. OA is present in the form of minor porosities on the left superior facets of C3 and C5, and the left inferior facet of C6. Lipping around the margin of the articulation is evident on the left inferior articulation of C4 and the left superior facet of C5. Minor porosities are present in the thoracic region on the right and left inferior facets of T3 and T9, the left superior and right inferior facets of T10, and all four articulations of T4. T4 also exhibits minor porosities on the costal facet of the right transverse process. In the lumbar vertebrae, lipping is present on the left inferior facet of L1, right and left inferior facets of L4, and all four facets of L5. Moderate osteophyte development is also present around the margins of the bodies of L4 and L5. The sacrum exhibits OA in the form of lipping around the superior articular facets of S1.

CATKEY: 339160 Age: 35-49 yrs. Sex: Male

The remains of this middle adult male include one unidentified cervical vertebra, and complete thoracic and lumbar segments. A complete five element sacrum is also included. Minor porosities are present on the right inferior facet of T5, right superior facet of T6, left inferior facet of T9, right and left inferior facets of T10, all four facets of T11, and the right and left superior facets of T12. Eburnation with erosion and lipping are present at the articulations between T10, T11, and T12. The costal facets on the transverse processes are involved on both sides of T6 and T10, and the right sides of T8 and T9. There is even eburnation on the costal facets of the transverse processes of T10, showing bone on bone contact between the ribs and this vertebra. Numerous Schmorl's nodes are present in the thoracic and lumbar segments, including depressions on both the superior and inferior aspects of the bodies of T5, T7, T8, T9, T10, T11, L1 and L2. Single Schmorl's nodes are present on the inferior aspect of the bodies of T4, L3, and L4. No pathologies are noted on the sacrum.

CATKEY: 339161A Age: 35-49 yrs. Sex: Female

There are 19 presacral vertebrae and a complete six element sacrum included with the remains of this middle adult female. The missing vertebrae include C3 through C7. No pathologies are noted in the cervical vertebrae. The only changes present in the thoracic vertebrae involve osteoarthritic remodeling of the right costal facet on the transverse process of T9, right and left costal facets on the body of T11, and the right costal facet of T12. In the lumbar vertebrae, mild OA is present in the form of lipping on the left inferior articular facet of L2 and the left inferior and superior facets of L3. The left and right superior facets of L4 also exhibit moderate lipping. The articulations between L4 and L5 exhibit severe remodeling, including porosities, lipping, eburnation, and erosion. The left inferior facet of L5 and left superior facet of S1 also show severe OA, with porosities, lipping, eburnation, and erosion. The six element sacrum includes a first coccygeal element fused to the sacrum. The inferior articulations of S1 are not completely fused to the superior articulations of S2.

CATKEY: 339162 Age: 20-34 yrs. Sex: Male

A complete 24 element presacral vertebral column and six element sacrum accompany the remains of this young adult male. The cervical vertebrae contained severe OA of the articular facets of C2 through C6. The left inferior articulation of C2 contained moderate lipping and eburnation. C3 showed lipping and eburnation on the left superior and right and left inferior articulations. Porosities, lipping and eburnation were also present on the left superior facet of C4, while the right superior and inferior articulations showed porosities and eburnation without lipping. Eburnation was also present between the right inferior and right superior articular facets of C5 and C6 respectively. In the thoracic segment, minor porosities are present on the right inferior articulations of both T4 and T5. A small amount of syndesmophyte development is also present between the superior articular facets of T7, T10, and T11. No pathologies or anomalies are present in the lumbar vertebrae. The sacrum has six complete elements, with the inferior articular facets of S1 not complete fused to those of S2. There are also porosities due to OA on the left sacro-iliac articulation.

CATKEY: 339163 Age: 15-19 yrs. Sex: Indeterminate

The remains of this late adolescent include a complete 24 element presacral vertebral column and a complete, although unfused, sacrum. The only anomaly present is a cleft in the dorsal bodies of the second and third cervical vertebrae (Figures 19 & 20). There was no trauma associated with this condition and it is most likely a congenital disorder. The body of C2 is less affected than that of C3 and some bony bridging was noted near the superior margin of the centrum of C3. The clinical significance of the condition for this individual is also not known, however, it may have been a contributing factor in their early death. No other pathologies are present in the vertebrae of this young individual.

CATKEY: 339207A Age: Adult, unknown Sex: Indeterminate
Only four vertebrae are associated with the few fragmentary remains of this individual. Included are C1, L4, L5, and one unidentified thoracic vertebra. C1 exhibits OA on all four articular facets and the articulation for the odontoid process. Both inferior facets and the facet for the odontoid process show porosities, erosion, and eburnation. The superior articular facets both have a deep bowl shaped appearance. This condition most likely related to a similar condition on the occipital condyles, but unfortunately the cranium was not recovered. OA is also present on all four articular facets of both L4 and L5. Both L4 and L5 have extreme osteophyte development with fused bone spicules around the margins of the bodies. A single Schmorl's node is present on the inferior body of L4. The bodies of L4 and L5 exhibit moderate biconcavity, resulting from osteoporosis. The unidentified thoracic vertebra has OA on the right inferior articular facet. The body of this vertebra is completely compressed from osteoporosis, and there is what appears to be a Schmorl's node on the superior aspect. No other observations are possible.

CATKEY: 339207B Age: Adult, unknown Sex: Indeterminate
Only C1 and C2 are present for this adult individual. No pathologies or anomalies are present on these two bones.

CATKEY: 339207C Age: Adult, unknown Sex: Indeterminate
Only C1 and C2 are present for this adult individual. The right and left superior articulations of C1 exhibit moderate lipping around the margins and surface erosion of the facets associated with OA.

CATKEY: 339207D Age: Adult, unknown Sex: Indeterminate

This individual consists only of C2 and two unidentified cervical vertebrae. No pathologies or anomalies are present.

CATKEY: 339207E Age: Adult, unknown Sex: Indeterminate

Only one unidentified cervical vertebra is present for this individual. No pathologies are present.

CATKEY: 339228 Age: 20-34 yrs. Sex: Female

The remains of this young adult female include only C2 and C3 with the cranium. C2 and C3 are fused at the bodies and arches, with the exception of the pedicles. This is most likely a case of Klippel-Feil syndrome, associated with segmentation failure during development. There was no evidence of arthritis or osteophytosis on either vertebra.

CATKEY: 339230 Age: 35-49 yrs. Sex: Male

A complete five element sacrum and no presacral vertebrae are associated with this middle adult male. Both superior articulations of S1 exhibit OA in the form of porosities, lipping and eburnation of the surfaces of the facets. Porosities are also present on the sacro-iliac joints on the left and right sides.

CATKEY: 339231 Age: 20-34 yrs. Sex: Male

Twenty-three presacral vertebrae and a complete five element sacrum are included with the remains of this young adult male. The only missing vertebra is L4. OA is present in nearly every presacral vertebra present. Remodeling of the articular facets in the cervical vertebrae is seen on all four facets of C1 and C3, the left inferior facets of C2, C4, and C5, the right superior facet of C6, and the right and left inferior facets of C7. In the thoracic segment, remodeling associated with OA is present on throughout. The greatest amount of change is seen between the left inferior articulation of T4 and left superior articulation of T5, and the right and left inferior and superior articulations of

T10 and T11 respectively. These joints both show porosities, lipping, eburnation, osteophytes, and erosion. The costal facets on the transverse processes of T6 through T9 also show osteoarthritic remodeling. Single Schmorl's nodes are present in the thoracic vertebrae on the superior aspect of T1, both the superior and inferior bodies of T5 and T7, and the superior body of T10. T11 exhibits two Schmorl's nodes on the inferior aspect of the body, as well as wedging of the ventral side of the superior aspect of the body. The superior articular facets of T12 exhibit what appear to be developmental grooves dividing the articulations in half. The left inferior articulation of T12 resembles a normal thoracic facet, facing anteriorly, rather than laterally. In the lumbar vertebrae, OA is present on all four articular facets of L1 and the right and left inferior facets of L2. L1 exhibits single end-plate depression with wedging of the ventral portion of the body. L2 has a Schmorl's depression on the superior aspect of the body. No pathologies or anomalies are present on the sacrum.

CATKEY: 339232 Age: 35-49 yrs. Sex: Female

The remains of this middle adult female include 22 presacral vertebrae and a complete six element sacrum. The vertebrae missing include C4 and C6. In the cervical vertebrae, mild lipping around the left superior articular facet of C1 is the only pathology present. The thoracic vertebrae show mild osteoarthritic remodeling of the right inferior facet of T9, right superior facet of T10, the right costal facets on the bodies of T9 and T10, and right and left costal facets on the bodies of T11 and T12. The lumbar vertebrae exhibit OA on the right and left inferior facets of L1 and the right and left superior facets of L2. Mild spondylolisthesis is present between L4 and L5. As a result, the superior anterior body surface of L5 has a rounded appearance. Mild to moderate osteophytes are present on L3 through L5, increasing in severity caudally. The six element sacrum includes a fused first coccygeal vertebra. The spinous process of S1 also appears to have been incompletely fused, resulting in slight *spina bifida occulta*, involving only this one sacral element.

CATKEY: 339233A Age: 20-34 yrs. Sex: Male

There are only five vertebrae and a complete five element sacrum associated with the remains of this young adult male. The vertebrae include C2 and a single unidentified cervical vertebra, two unidentified thoracic vertebrae, and L5. The only pathology noted in these few remains is a severe fracture through the body of L5. The fracture extends through the right side of the vertebral body and halfway through the lamina, from the superior border near the spinous process into the *pars interarticularis*. No healing of this fracture is present, suggesting that the injury occurred at or near the time of death. No pathologies or anomalies are associated with the sacrum.

CATKEY: 339233B Age: Adult, unknown Sex: Indeterminate

The remains of this adult individual consist solely of seven cervical vertebrae. There are no pathologies or anomalies present and all show slight taphonomic erosion associated with weathering.

CATKEY: 339233C Age: Adult, unknown Sex: Indeterminate

The remains of this adult are comprised of only C2 and a single unidentified cervical vertebra. Both vertebrae exhibit severe taphonomic erosion, making observations on pathologies impossible.

CATKEY: 339234 Age: 35-49 yrs. Sex: Female

The remains of this middle adult female include a complete 24 element presacral vertebral column and five element sacrum. Major OA is present throughout nearly the entire vertebral column. The only vertebrae that do not seem to have any remodeling are C2, C7, T1, and T2. The most severe OA, including eburnation, is present at the joints between C3/C4, C4/C5, T3/T4, T4/T5, T5/T6, T11/T12, L3/L4, and L4/L5. The bodies of C4 and C5 even exhibit severe remodeling and eburnation associated with complete degenerative disc disease at this joint. The costal facets on the bodies of T6 through T12 all exhibit osteoarthritic remodeling, as do the costal facets on the transverse processes of T3, T4, and T9. Schmorl's nodes are present on the inferior aspect of the body of C5, and the superior and inferior body surfaces of L1. OA is also present on both superior articular facets of the sacrum.

CATKEY: 339235 Age: 10-14 yrs. Sex: Ambiguous subadult

The only vertebrae present for this adolescent child are C1 through C4. C2 and C3 for this individual exhibit congenital fusion (segmentation failure) and are connected from the articular facets through the spinous processes of the two vertebrae. This condition is most likely a congenital defect known as Klippel-Feil syndrome, associated with segmentation failure during development. There was no evidence of arthritis or osteophytosis on either vertebra. The superior facets of C4 exhibit mild porosities, however this is most likely a result of the fused vertebrae above.

CATKEY: 339239A Age: 20-34 yrs. Sex: Male

The sacrum is the only portion of the vertebral column present for this young adult male. It is a five element sacrum that seems to have had a generalized infection at the time of death. Bone remodeling on the dorsal aspects of S1 through S3, give the bone a honeycomb like appearance. Unfortunately, no radiographs are available and the only other bones present are the left and right innominates, which do not show evidence of infection.

CATKEY: 339239B Age: 14-19 yrs. Sex: Ambiguous subadult

The pelvis, including the sacrum and both innominates, is all that remains of this late adolescent. The sacrum appears to have had five elements, but S5 was broken off postdepositionally. The articular facets of S1 through S4 are fused, but the bodies are not. Complete *spina bifida occulta* is present, with a completely open neural canal. Like the individual above, there appears to have been an infection in the area of S1 and S2, based on the honeycomb appearance of remodeling bone on the dorsal aspects of these two segments.

CATKEY: 339239C Age: 20-34 yrs. Sex: Male

A complete five element sacrum is included with the left and right innominates of this young adult male. No pathologies or anomalies are present on this lightly weathered bone.

CATKEY: 339239D Age: 35-49 yrs. Sex: Male

A complete six element sacrum is included with the pelvis of this middle adult male. Other than six complete elements, there are no other pathologies or anomalies noted in the sacrum.

CATKEY: 339239F Age: 15-19 yrs. Sex: Female

The pelvis of this late adolescent female includes a complete five element sacrum. The bodies of S1 and S2 are not fused and only partial fusion has taken place between S2 and S3 on the dorsal aspect. The inferior articulations of S1 and superior articulations of S2 are also not fused. Partial *spina bifida occulta* is present in the form of an unfused neural arch of S1 and a sacral hiatus that extends up through S3.

CATKEY: 339239I Age: Adult, unknown Sex: Ambiguous

The sacrum is all that remains of this adult individual. It is comprised of six elements, including a fused first coccygeal vertebra. No other pathologies or anomalies are noted.

CATKEY: 339239J Age: Adult, unknown Sex: Probable male

A complete five element sacrum is all that remains of this adult, listed as a probable male. It appears that this individual suffered from a generalized infection based upon the bone remodeling of the right and left dorsal surface of S1, S2, and the right side of S3, giving it a honeycomb appearance. No other pathologies or anomalies are noted.

CATKEY: 339239K Age: Adult, unknown Sex: Probable female

This adult, classified as a probable female, also includes only a fragmentary four element sacrum. There is a clear articulation for a sacralized lumbar vertebra on the superior aspect of the ala of S1. OA is present on the right and left superior articular facets, as well as the right and left articulations with the innominates.

CATKEY: 3392390 Age: 35-49 yrs. Sex: Male

A complete five element sacrum is included with the pelvis of this middle adult male. No pathologies or anomalies are noted for this individual.

CATKEY: 339243 Age: 20-34 yrs. Sex: Female

The first and second cervical vertebrae are the only vertebrae included with the cranium of this young adult female. No pathologies or anomalies are present.

CATKEY: 339245 Age: 14-19 yrs. Sex: Probable female

The first and second cervical vertebrae are the only vertebrae included with the cranium of this late adolescent probable female. No pathologies or anomalies are present.

CATKEY: 339246 Age: 35-49 yrs. Sex: Female

The first cervical vertebra and two unidentified cervical vertebrae are included with the cranium of this middle adult female. All three of the vertebrae are badly weathered, thus making observations impossible.

CATKEY: 339247 Age: 35-49 yrs. Sex: Female

The first and second cervical vertebrae are the only vertebrae included with the cranium of this middle adult female. Some small osteophytes are present on the left distal margin of the left superior articulation, but erosion from weathering prohibits further observations.

CATKEY: 339252 Age: 35-49 yrs. Sex: Female

The vertebral remains of this middle adult female include C1, C3 through C7, T7 through T12, L1, L2, L4, and L5. A complete six element sacrum is also present. OA is present in the cervical region on the right inferior articulation of C3 and the left inferior articulation of C4. In the thoracic vertebrae, the right and left superior articular facets of both T8 and T9 exhibit osteoarthritic remodeling as does the costal facet on the left transverse process of T10. Mild osteophyte development is present around the margins of the bodies of T7 through T12. All four lumbar vertebrae present exhibit OA on all articular facets. Although, the left inferior facet on L4 and left superior on L5 are much more severely affected. This joint shows porosities, lipping, eburnation, and erosion of the articular surfaces. Mild osteophytosis is also present on L2 and L4. The six element sacrum includes a fused first coccygeal element. OA is present on both the right and left sacro-iliac articulations on the sacrum.

CATKEY: 339254 Age: 35-49 yrs. Sex: Male

The remains of this middle adult male include C1, C2, two unidentified cervical vertebrae, T1, T5 through T8, T12, L1 through L4, and a complete five element sacrum. No pathologies or anomalies are present in the cervical vertebrae. In the thoracic region, the right and left inferior articulations of T6, left inferior facet of T7, and left superior and right and left inferior facets of T8 all exhibit mild to moderate OA. The most severely affected are T7 and T8, which both show erosion of the joint surfaces. All four lumbar vertebrae present exhibit Schmorl's nodes. On L1 a single depression is located on the inferior aspect of the body. L2 has a depression on the superior aspect corresponding to the depression on L1. Single Schmorl's depressions are also located on both the superior and inferior aspects of the body of L3 and the superior body of L4. Mild osteophytosis is also present around the margins of the bodies of all four lumbar vertebrae. L2 exhibits some anomalous bone remodeling that appears to have been active at the time of death, around the anterior margin of the body is most likely related to a generalized infection. The right and left sides of the first two elements of the sacrum also exhibit this same type of bone remodeling.

CATKEY: 339256 Age: 35-49 yrs. Sex: Probable male

A nearly complete presacral vertebral column and a complete five element sacrum are included with the remains of this middle adult probable male. The only missing vertebrae are L1 and L5. There is massive remodeling throughout the vertebrae of this individual. Because of the extensive nature of the pathologies, they will be described by individual vertebra for this individual. C1 exhibits OA on the articulation for the odontoid process, including lipping and eburnation of the facet. Eburnation is also present on the odontoid process of C2, as well as on the right and left inferior articular facets of C2. There is a bony spur on the superior edge of the odontoid process that appears to be the result of the osteoarthritic remodeling of this joint. OA is present on the right and left articulations of C3, as well as over the entire inferior aspect of the body of the vertebra. C4 shows similar remodeling on both the superior and inferior aspects of the body and the right superior and inferior articular facets. C5 also exhibits OA on the right superior and inferior articulations. The body of C5 has single end-plate depression with wedging of the supero-anterior aspect. It appears as if there may have been a Schmorl's node on the inferior body surface, but erosion of the body is so severe that it is impossible to determine. The body of C6 is collapsed completely, most likely as a result of severe osteoporosis. C6 also exhibits OA on the right inferior articular facets. Both left articulations are unobservable because of erosion on C6 and C7. C7 has OA of the right superior and inferior articulations. The body of C7 appears to have suffered from severe erosion associated with osteoporosis, resulting in compression on the superior aspect without wedging. Schmorl's nodes are also present on both the superior and inferior body surfaces of C7. In the thoracic vertebrae, the costal facets on the bodies all exhibit OA and mild to moderate osteophytosis is present throughout. Osteophyte development is most severe in the lower mid-thoracic segment (T5 through T10). T1 has a Schmorl's node on the superior aspect of the body and porosities associated with osteoporosis on the right superior margin of the body. The right and left superior articulations of both T2 and T3 show only mild lipping from OA. T4 has what appears to be a fissure, most likely a large intervertebral disc herniation, extending from the inferior posterior margin of the body to about two-thirds of the way anteriorly across the body (13 mm). There has been some osteophytic remodeling around the opening into the vertebral body. The right and left inferior articular facets of T4 also show mild OA. The same type of large fissure Schmorl's nodes are present on both the superior and inferior aspects of the body of T5. The superior fissure is centered on the body and is 9 mm in length, while the inferior fissure is 19 mm in length and extends from the posterior margin across most of the body. Osteophytes are present around the margins of both of the fissures. The right superior and inferior articulations of T5 also show mild OA. Schmorl's depressions are present on the superior and inferior surfaces of T6 also. The superior node is small (4 mm) and centered on the body. The inferior depression is a large fissure, 20 mm in length and 9 mm wide at its widest point. This fissure covers most of the vertebral body and is surrounded by porosities and actively remodeling bone. Mild OA is present on the right superior and inferior articular facets of T6. T7 exhibits a single fissure type Schmorl's depression on the inferior surface of the vertebral body. The fissure is 19 mm in length, extending anteriorly from the posterior margin of the body. There is a considerable amount of remodeling around the margins of the fissure. The right superior and inferior articular facets of T7 show mild OA. The superior aspect of the body of T8 has osteophytic remodeling near the center, while the inferior has severe bone loss associated with osteoporosis, with large porosities covering most of the surface. The articular facets of T8 are also affected with mild OA. T9 shows similar porosities to T8, even forming a "v" shape on the superior aspect of the body. Extensive porosities and bone loss obscure a possible Schmorl's node on the inferior aspect of the body of T9. The right and left inferior articular facets of T9 show severe OA with extensive erosion of the joint surfaces and mild eburnation. All four articular facets of T10 are also affected in a similar fashion to those of T9. The body of T10 has a transverse depression across the inferior aspect of the body that measures 23 mm in length. The right end of the depression penetrates the outer table of bone. A Schmorl's depression is located on the inferior aspect of the body of T11, forming a "u" shaped opening along the posterior margin of the body, 12 mm towards the anterior. There are lesions on the lamina on both the right and left sides near *pars interarticularis* of T11 giving the bone a moth-eaten appearance. The right and left superior articular facets of T11 have extensive OA with erosion of the joint surface and eburnation. The body of T12 has minor porosities on the superior surface, but the inferior surface has two Schmorl's depressions extending anteriorly from near the posterior margin for 9 mm. The depressions are 3 mm wide and both penetrate the outer table of bone. The superior aspect of the body exhibits single end-plate depression with wedging. Lesions are present on both laminae near *pars interarticularis*. The bone has thinned to such an extent that it is translucent in some places. T12 also has minor OA of all four articular facets. In the lumbar segment, L2 has a Schmorl's depression that extends transversely across the superior aspect of the vertebral body with penetrating the outer table of bone, 24 mm in length. The right and left superior articulation of L2 have moderate OA. L3 has a large Schmorl's depression extending transversely across the superior aspect of the body and two small porosities on the inferior surface that appear to penetrate the outer table of bone. The right superior facet of L3 is also affected by mild OA. The right and left superior articular facets of L4 have extensive osteoarthritic remodeling with eburnation and erosion of the joint surface. All three lumbar vertebrae present exhibit severe osteophyte development with fused spicules and porosities around the margins of the bodies, as well as within the margins of the bodies. No pathologies or anomalies are present on the sacrum.

CATKEY: 339257 Age: 20-34 yrs. Sex: Female

The remains of this young adult female include 23 presacral vertebrae and a complete five element sacrum. The only missing vertebra is L5. The margins of the bodies of the thoracic (except T3, T4, and T7) and lumbar vertebrae are badly eroded taphonomically, making observations of osteophytosis impossible. No pathologies or anomalies are present in the cervical vertebrae. The thoracic vertebrae show mild OA on the right and left inferior facets of T5 and the left superior facet of T6. The left superior and inferior articular facets of L1 through L4 all show approximately the same amount of osteoarthritic remodeling, with slight to moderate lipping of the joint surfaces. The sacrum exhibits OA of both the right and left sides of the sacro-iliac joints, with porosities, lipping, and osteophyte development. The left and right ala of the sacrum show some bone loss that results in a depression 20 mm in diameter. The depressions are most likely the result of penetration of a bony spur that has developed on the on the middle of the iliac tuberosity measuring approximately 9 mm in length.

CATKEY: 339258A Age: 20-34 yrs. Sex: Female

There are 18 presacral vertebrae and a complete sacrum included with the remains of this young adult female. The only cervical vertebrae present are C1 and C2, neither of which have any pathologies or anomalies. In the thoracic segment, T2 is missing. Mild OA is present on the right inferior articulation of T5, the left costal facet of the transverse process of T10, and the right inferior articulation of T12. In the lumbar region, the right superior facet of L1, the right and left superior articulations of both L2 and L3, and all four articular facets of L4 and L5 exhibit moderate lipping around the joint surfaces. The superior articular facets of the sacrum also have lipping from OA. The inferior articular facets of S1 are not fused to the superior facets of S2. The sacro-iliac articulations on both sides of the sacrum have porosities and moderate bone remodeling from an unknown source.

CATKEY: 339259 Age: 15-19 yrs. Sex: Probable male

There are 23 presacral vertebrae and a complete six element sacrum associated with the remains of this late adolescent probable male. The only vertebra missing was C5. This individual apparently suffered from a massive systemic infection, resulting in abnormal bone loss of most long bones, the innominates, and even the cranium. In the vertebrae, bone loss has resulted in T7 through T12 having a porous appearance to the margins of the vertebral bodies. The left and right sides of S1 through S3 in the sacrum are also similarly affected. In the cervical vertebrae, the neural arch of C1 appears to be congenitally unfused. C1 also has a completely separated superior articular facet on the left side. C7 has a split in the left superior articular facet that is of unknown origin, although trauma does not appear to have been the cause. The corresponding articular facet on C6 does not reflect the changes to that of C7. Mild to moderate osteoarthritic remodeling is present on the right inferior facet of T5, right superior facet of T7, left inferior facet of T9, left superior and right and left inferior facets of T10, right and left superior facets of T11, and all four articular facets of T12. A Schmorl's depression extends transversely across the inferior aspect of the body of T7. This depression penetrates the outer table of bone along the outer margins only. A slight Schmorl's node is also present on the superior aspect of the body of T8. In the lumbar segment, mild to moderate OA is present on all four articular facets of L1 and L4, the right superior facet of L2, and the right and left inferior facets of L3. A single Schmorl's node is present on the superior aspect of the body of L2 that does not penetrate the outer table of bone. On the sacrum, the sixth element is a fused first coccygeal vertebra.

CATKEY: 339260 Age: 35-49 yrs. Sex: Male

The remains of this middle adult male include 23 presacral vertebrae (missing only T3), and a complete five element sacrum. The right and left inferior articulations of C1 and the right and left superior articulations of C2 show moderate OA with lipping around the joint margins. Both of the inferior articular facets of C3 have small grooves of unknown origin. They are not associated with osteoarthritis and there is nothing present on the superior articulations of C4 that would cause this type of anomaly. In the thoracic vertebrae, the costal facets on the right and left transverse processes of T4 and the costal facets on the right transverse processes of both T7 and T9 have lipping associated with OA. Many of the costal facets on the bodies of the thoracic vertebrae also exhibit very mild porosities associated with OA. Moderate OA is also present on the left inferior facet of T7, left superior facet of T8, and right inferior facet of T10. More severe OA with eburnation is present between the left inferior facet of T11 and the left superior facet of T12. The articular facets between T12 and L1 also exhibit OA with porosities, lipping, and erosion of the joint surfaces. A single Schmorl's depression is present on the inferior aspect of the body of T7. T8 also exhibits single Schmorl's nodes on both the inferior and superior aspects of the body. Multiple Schmorl's nodes are present on the body of T9, including three on the superior surface and two on the inferior surface. The inferior anterior margin of the body of T12 has been extended slightly to compensate for the changes to the body of L1. The body of L1 exhibits double end-plate compression with Schmorl's nodes on both the superior and inferior surfaces of the body. L2 has Schmorl's nodes on both the superior and inferior aspects of the body, whereas L3 has a single Schmorl's node on the inferior surface of the body. Moderate OA is present in the lumbar vertebrae on the right superior facet of L3 and all four articular facets of L4 and L5. The right inferior facet of L5 and the right superior facet on the sacrum show remodeling including lipping, eburnation, and erosion of the joint surfaces.

CATKEY: 340177 Commingled remains of six individuals
Individual 1: C1 with lipping around the margins of all four articular facets and the articulation for the odontoid process.

Individual 2: C1 with OA around the margin of the articulation for the odontoid process.

Individual 3: C1 with lipping around the margins of both superior articular facets and minor osteophyte development around the right superior facet.

Individual 4: C1 with porosities, lipping, eburnation, and erosion of the joint surface of the left superior articular facet.

Individual 5: C2 showing no pathologies or anomalies.

Individual 6: C2 that is small in size with a portion of the right side of the arch broken off postmortem. No pathologies or anomalies present.

Table C1. Inventory of cervical vertebrae and spinal pathologies in the Nunivak Island collection.

Catno	Sex	Age	C1	OA	C2	OA	SN	C3	OA	SN	C4	OA	SN	C5	OA	SN	C6	OA	SN	C7	OA	SN	UIC	#C
339103	5	6	1	-	1	-	-	1	-	-	1	-	-	1	-	-	0	-	-	1	-	-	0	6
339104A	1	6	1	-	1	-	-	1	-	-	1	-	-	1	-	-	0	-	-	1	-	-	0	6
339106	1	8	1	-	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	0	7
339107	1	7	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	-	-	1	4
339108	1	8	0	-	1	-		1	-	-	1	-	-	0	-	-	1	-	-	1	-	-	0	5
339109	1	8	1	X	1	X	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339131	2	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339132	2	8	0	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	-	-	0	5
339133	1	7	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339134A	2	7	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339137	2	8	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339138	1	9	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339139	1	8	1	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
339140	2	8	1	-	1	-	-	1	-	-	0	-	-	1	-	-	1	-	-	0	-	-	0	5
339145	1	8	0	-	0	-	-	1	-	-	0	-	-	1	-	-	0	-	-	0	-	-	0	2
339146A	5	9	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339147	2	8	0	-	0	-	-	0	-	-	0	-	-	1	-	-	1	-	-	1	-	-	0	3
339152	3	3	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339153	3	5	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339154	2	8	0	-	0	-	-	1	X	-	1	X	-	1	X		1	X	-	1	X	-	0	5
339156A	2	8	1	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
339157	2	8	0	-	0	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	5
339158	1	7	1	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
339159	2	8	1	-	1	-	-	1	X	-	1	X	-	1	X	-	1	X	-	1	-	-	0	7
339160	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	1
339161A	2	8	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339162	1	7	1	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	-	-	0	7
339163	3	6	1	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
339207A	3	11	1	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	1
339207B	3	11	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339207C	3	11	1	X	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339207D	3	11	0	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	2	3
339207E	3	11	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	1
339228	2	7	0	-	1	-	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339230	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339231	1	7	1	X	1	X	-	1	X	-	1	X		1	X		1	X	-	1	X	-	0	7
339232	2	8	1	X	1	-	-	1	-	-	0	-		1	-	-	0	-	-	1	-	-	0	5
339233A	1	7	0	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	2
339233B	3	11	1	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1		-	0	7
339233C	3	11	0	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	2
339234	2	8	1	X	1	-	-	1	X	-	1	X	-	1	X	X	1		-	1	-	-	0	7
339235	6	5	1	-	1	-	-	1	-	-	1	-	-	0	-	-	0	-	-	0	-	-	0	4
339239B	1	6	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239F	2	6	0	-	0	-	-	0	-	-	0	-	-	0	-		0	-	-	0	-	-	0	0
339239A	1	7	0	-	0	-	-	0	-	-	0	-		0	-		0		-	0	-	-	0	0
339239C	1	7	0	-	0	-	-	0			0			0	-	-	0	-	-	0	-	-	0	0

Table C1. Inventory of cervical vertebrae and spinal pathologies in the Nunivak Island collection continued.

Catno	Sex	Age	C1	OA	C2	OA	SN	C3	OA	SN	C4	OA	SN	C5	OA	SN	C6	OA	SN	C7	OA	SN	UIC	#C
339239D	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239O	1	8	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239J	4	11	0	-	0	-	-	0	-	-	0		-	0	-	-	0	-	-	0	-	-	0	0
339239K	5	11	0	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239I	6	11	0	-	0		-	0	-	-	0	-	-	0	-		0	-	-	0	-	-	0	0
339243	2	7	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339245	4	6	1	-	1	-	-	0		-	0	-	-	0	-		0	-	-	0	-	-	0	2
339246	2	8	1	-	0	-	-	0	-		0	-	-	0	-	-	0	-	-	0	-	-	2	3
339247	2	8	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339252	2	8	1	-	0	-	-	1	X	-	1	X	-	1	-	-	1	-	-	1		-	0	6
339254	1	8	1	-	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339256	4	8	1	X	1	X	-	1	X	-	1	X		1	X	-	1	X	-	1	X	X	0	7
339257	2	7	1	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7
339258A	2	7	1	-	1		-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339259	4	6	1	-	1	-	-	1		-	1	-	-	0		-	1	-	-	1	-	-	0	6
339260	1	8	1	X	1	X	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	7

Sex: 1 = male, 2 = female, 3 = indeterminate, 4 = probable male, 5 = probable female, 6 = ambiguous

Age: 1 = fetal, 2 = newborn - 0.9 yrs, 3 = 1 - 4 yrs, 4 = 5 - 9 yrs, 5 = 10 - 14 yrs, 6 = 15 - 19 yrs, 7 = 20 - 34 yrs, 8 = 35 - 49 yrs, 9 = 50 +,
10 = subadult, age indeterminate, 11 = adult age indeterminate, 12 = unknown

For each cervical vertebra, 1/0 denotes presence/absence

OA = osteoarthritis, SN = Schmorl's node, X = presence of condition

UIC = unidentified cervical vertebrae

#C = number of cervical vertebrae

Table C2. Inventory of thoracic vertebrae and spinal pathologies in the Nunivak Island collection.

Catno	Sex	Age	T1	OA	SN	T2	OA	SN	T3	OA	SN	T4	OA	SN	T5	OA	SN	T6	OA	SN	T7	OA	SN	T8	OA	SN	T9	OA	SN	T10	OA	SN	T11	OA	SN	T12	OA	SN	UTT	#T
339103	5	6	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339104A	1	6	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339106	1	8	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	-	-	1	X	-	0	12
339107	1	7	1	-	-	0	-	-	0	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	10
339108	1	8	1	X	-	0	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	0	-	-	1	X	-	0	10
339109	1	8	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	-	-	1	X	-	1	X	-	0	8
339131	2	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339132	2	8	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	0	12
339133	1	7	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339134A	2	7	1	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	2
339137	2	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	X	-	1	-	-	1	X	-	0	-	-	2	5
339138	1	9	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	X	-	1	2
339139	1	8	0	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	11
339140	2	8	1	-	-	0	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	1	X	X	1	X	-	0	11
339145	1	8	1	X	-	1	X	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	2
339146A	5	9	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339147	2	8	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339152	3	3	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339153	3	5	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339154	2	8	0	-	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	0	11
339156A	2	8	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	0	12
339157	2	8	1	-	-	1	-	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	0	12
339158	1	7	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339159	2	8	1	-	-	1	-	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	1	-	-	1	-	-	0	12
339160	1	8	1	-	-	1	-	-	1	-	-	1	-	X	1	X	X	1	X	-	1	-	X	1	X	X	1	X	X	1	X	X	1	X	X	1	X	-	0	12
339161A	2	8	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	-	-	1	X	-	1	X	-	0	12
339162	1	7	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339163	3	6	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	0	12
339207A	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	1
339207B	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339207C	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339207D	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339207E	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339228	2	7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339230	1	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339231	1	7	1	X	X	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	X	1	X	-	1	X	-	1	X	X	1	X	X	1	X	-	0	12
339232	2	8	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X	-	1	X	-	1	X	-	0	12
339233A	1	7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	2	2
339233B	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339233C	3	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339234	2	8	1	-	-	1	-	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	1	X	-	0	12
339235	6	5	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239B	1	6	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239F	2	6	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239A	1	7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239C	1	7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0

Table C2. Inventory of thoracic vertebrae and spinal pathologies in the Nunivak Island collection continued.

Catno	Sex	Age	T1	OA	SN	T2	OA	SN	T3	OA	SN	T4	OA	SN	T5	OA	SN	T6	OA	SN	T7	OA	SN	T8	OA	SN	T9	OA	SN	T10	OA	SN	T11	OA	SN	T12	OA	SN	UTT	#T
339239D	1	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239O	1	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239J	4	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239K	5	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339239I	6	11	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339243	2	7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339245	4	6	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339246	2	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339247	2	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	0
339252	2	8	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	-	-	1	X	-	1	X	-	1	X	-	1	-	-	1	-	-	0	6
339254	1	8	1	-	-	0	-	-	0	-	-	0	-	-	1	-	-	1	X	-	1	X	-	1	X	-	0	-	-	0	-	-	0	-	-	1	-	-	0	6
339256	4	8	1	X	X	1	X	-	1	X	-	1	X	X	1	X	X	1	X	X	1	X	X	1	X	-	1	X	-	1	X	X	1	X	X	1	X	X	0	12
339257	2	7	1	-	-	1	-	-	1	-	-	1	-	-	1	X	-	1	X		1	-	-	1		-	1			1	-	-	1	-	-	1	-	-	0	12
339258A	2	7	1	-	-	0	-	-	1	-	-	1	-	-	1	X	-	1			1	-	-	1	-	-	1		-	1	X	-	1	-	-	1	X		0	11
339259	4	6	1	-	-	1	-	-	1	-	-	1			1	X	-	1			1	X	X	1	-	X	1	X		1	X	-	1	X	-	1	X	-	0	12
339260	1	8	1	-	-	1	-	-	0	-	-	1	X	-	1	-	-	1	-		1	X	X	1	X	X	1	X	X	1	X	-	1	X	-	1	X		0	11

Sex: 1 = male, 2 = female, 3 = indeterminate 4 = probable male, 5 = probable female 6 = ambiguous
Age: 1 = fetal, 2 = newborn - 0.9 yrs, 3 = 1 - 4 yrs 4 = 5 - 9 yrs 5 = 10 - 14 yrs 6 = 15 - 19 yrs 7 = 20 - 34 yrs 8 = 35 - 49 yrs 9 = 50 +
10 = subadult, age indeterminate, 11 = adult age indeterminate 12 = unknown
For each thoracic vertebra, 1 0 denotes presence absence
OA = osteoarthritis, SN = Schmorl's node, X = presence of condition
UTT = unidentified thoracic vertebrae
#T = number of thoracic vertebrae

Table C3. Inventory of lumbar vertebrae and spinal pathologies in the Nunivak Island collection.

Catno	Sex	Age	L1	OA	SN	L2	OA	SN	SP	L3	OA	SN	L4	OA	SN	L5	OA	SN	UIL	#L
339103	5	6	1	-	-	1	-	-		1		-	1	-		1	-		0	5
339104A	1	6	1	-	-	1	-	-	-	1	-	-	1	-		1		-	0	5
339106	1	8	1	X	-	0	-	-		0	-	-	1	X	-	1		-	0	3
339107	1	7	1	-	-	1		-		1	-	-	1	-	-	1	-		0	5
339108	1	8	1	-	-	1	X	-	X	1	X	-	1	X	-	1		-	0	5
339109	1	8	1	-	-	1	-	-	-	1	X	-	1		-	1	X	-	0	5
339131	2	8	1	-	-	0				0	-	-	0	-	-	0	-	-	0	1
339132	2	8	1	-	-	1	X	-		1	X	-	1	X		1	X		0	5
339133	1	7	1	-	-	1	-	-	-	1			1			1			1	6*
339134A	2	7	0	-	-	0			-	0	-	-	0			0	-		0	0
339137	2	8	0	-		0	-	-	-	0	-		0	-	-	1	X	-	2	3
339138	1	9	1	X	-	0	-			0	-		0	-	-	0	-	-	0	1
339139	1	8	1	-	-	1	-	-	-	1	-	-	1	-	-	1	-		0	5
339140	2	8	1	X	-	1	X	-	-	1	X	-	1	X	-	1	X	-	0	5
339145	1	8	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339146A	5	9	0		-	0	-	-	-	0	-	-	0	-		0	-	-	1	1
339147	2	8	1	-	-	1	-	-	-	1	-	-	1	X	-	1	X	-	0	5
339152	3	3	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339153	3	5	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339154	2	8	1	X	-	1	X	-	-	1	X	-	1	X	-	1	X	-	0	5
339156A	2	8	1	-	-	1	-	-	-	1	X	X	1	X	-	1	X	-	0	5
339157	2	8	1	X	-	1	X	-	-	1	X	-	1	X	-	1	X	-	0	5
339158	1	7	1	X	-	1	X	-	-	1		-	1	-	-	1	X	-	0	5
339159	2	8	1	X	-	1	-	-	-	1	-	-	1	X	-	1	X	-	0	5
339160	1	8	1	X	X	1	X	X	-	1	X	X	1	X	X	1	X	-	0	5
339161A	2	8	1	-	-	1	X	-	-	1	X	-	1	X	-	1	X	-	0	5
339162	1	7	1	-	-	1	-	-	-	1	-	-	1	-	-	1	-	-	0	5
339163	3	6	1	-	-	1	-	-	-	1		-	1	-	-	1	-	-	0	5
339207A	3	11	0	-	-	0	-	-	-	0		-	1	X	X	1	X	-	0	2
339207B	3	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-		0	0
339207C	3	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339207D	3	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339207E	3	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339228	2	7	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339230	1	8	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339231	1	7	1	X	-	1	X	X	-	1	-	-	0	-	-	1	-	-	0	4
339232	2	8	1	X	-	1	X	-	-	1	-	-	1	-	-	1	-	-	0	5
339233A	1	7	0	-	-	0	-	-	-	0	-	-	0	-		1	-	-	0	1
339233B	3	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339233C	3	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339234	2	8	1	X	X	1	X	-	-	1	X	-	1	X	-	1	X	-	0	5
339235	6	5	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339239B	1	6	0	-	-	0		-	-	0	-	-	0	-	-	0	-	-	0	0
339239F	2	6	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339239A	1	7	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339239C	1	7	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0

Table C3. Inventory of lumbar vertebrae and spinal pathologies in the Nunivak Island collection continued.

Catno	Sex	Age	L1	OA	SN	L2	OA	SN	SP	L3	OA	SN	L4	OA	SN	L5	OA	SN	UL	#L
339239D	1	8	0	-	-	0	-	-		0	-	-	0	-	-	0	-	-	0	0
339239O	1	8	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339239J	4	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339239K	5	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339239I	6	11	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339243	2	7	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339245	4	6	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339246	2	8	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339247	2	8	0	-	-	0	-	-	-	0	-	-	0	-	-	0	-	-	0	0
339252	2	8	1	X	-	1	X	-	-	0	-	-	1	X	-	1	X	-	0	4
339254	1	8	1	X	X	1	X	X	-	1	X	X	1	X	X	0	-	-	0	4
339256	4	8	0	-	-	1	X	X	-	1	X	X	1	X	-	0	-	-	0	3
339257	2	7	1	X	-	1	X	-	-	1	X	-	1	X	-	0	-	-	0	4
339258A	2	7	1	X	-	1	X	-	-	1	X	-	1	X	-	1	X	-	0	5
339259	4	6	1	X	-	1	X	X	-	1	X	-	1	X	-	1	-	-	0	5
339260	1	8	1	X	X	1	X	X	-	1	X	X	1	X	-	1	X	-	0	5

Sex: 1 = male, 2 = female, 3 = indeterminate, 4 = probable male, 5 = probable female, 6 = ambiguous
Age: 1 = fetal, 2 = newborn - 0.9 yrs, 3 = 1 - 4 yrs, 4 = 5 - 9 yrs, 5 = 10 - 14 yrs, 6 = 15 - 19 yrs, 7 = 20 - 34 yrs, 8 = 35 - 49 yrs, 9 = 50 +,
10 = subadult, age indeterminate, 11 = adult age indeterminate, 12 = unknown
For each lumbar vertebra, 1/0 denotes presence/absence
OA = osteoarthritis, SN = Schmorl's node, SP = spondylolysis, X = presence of condition
UL = unidentified lumbar vertebrae, * includes 6th lumbar vertebra
#L = number of lumbar vertebrae

D Sample Statistics

The method for calculating the G statistic in a 2 X 2 contingency table is as follows:

	Column 1	Column 2	Totals
Row 1	*a*	*b*	
Row 2	*c*	*d*	
Totals			*n*

Step 1: Calculate the sum of the transforms for the individual cells using the formula, $\sum f \times \ln f$ where f is the cell value.

Step 2: Calculate the sum of the transforms for the row and column totals using the same formula as above, except that f represents the row and column totals.

Step 3: Calculate the transform of the grand total using the formula $n \times \ln n$.

Step 4: Calculate G. G = 2 X [Step 1 – Step 2 + Step 3].

Step 5: Calculate Williams' correction using the equation,

$$q = 1 + \frac{[(n/a+b)+(n/c+d)-1][(n/a+c)+(n/b+d)-1]}{6n}$$

Step 6: Divide the computed value of G by the correction value, $G_{adj} = G/q$.

Step 7: Compare the value of G_{adj} to the critical value of chi-square with one degree of freedom ($\chi^2_{.05[1]} = 3.841$). If the value of G_{adj} is less than $\chi^2_{.05[1]}$ then I would fail to reject the null hypothesis. The null hypothesis given the above 2 X 2 table is: The occurrence of the column variable is independent of the occurrence of the row variable.

Sample G-test using only adult individuals with complete L1 - L5.

Golovin Bay

Sex	Normal	W/Spondylolysis	Totals	% W/Spondylolysis
Male	4	8	12	66.7
Female	11	10	21	47.6
Totals	15	18	33	54.5

Sum of the transforms ($\sum f \ln f$) for the cell frequencies

1) 71.583

Sum of the transforms ($\sum f \ln f$) for the row and column totals

2) 186.401

Transform of grand total value (n ln n)

3) 115.385

Compute G value

4) G=2[quantity 1 - quantity 2 + quantity 3]

G= 1.134

Williams's correction is applied, resulting in a more conservative test.

q=1+[(((n/a+b)+(n/c+d)-1)((n/a+c)+(n/b+d)-1)))/6n]

q = 1.050883838

The computed value of G is then divided by the correction factor.

Gadj = G/q

Gadj = 1.079 X^2 .05[1] = 3.841

Because Gadj < X^2 .05[1] then I fail to reject the null hypothesis that occurrence of spondylolysis is independent of sex.

Formula for G-test from Sokal and Rohlf (1995)